Regional Operational Plan SF.1J.2015.17

Production and Harvest of Chilkat River Chinook and Coho Salmon, 2015–2016

by

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and

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September 2015

Alaska Department of Fish and Game Divisions of Sport Fish and Commercial Fisheries

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	\$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$log_{2,}$ etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL OPERATIONAL PLAN SF.1J.2015.17

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by

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SIGNATURE/TITLE PAGE

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Approval

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Biometrician	Sarah Power		7.16.15
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Chinook Salmon Research Initiative Approval

Title	Name	Signature	Date
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ABSTRACT

An ongoing coded-wire tag (CWT) project, used as part of a stock assessment program for Chilkat River Chinook salmon (*Oncorhynchus tshawytscha*) and coho salmon (*Oncorhynchus kisutch*), will be conducted during fall 2015 and spring 2016 to provide estimates of smolt abundance and marine harvest for Chinook and coho salmon. The CWT project uses modified Peterson 2-event mark-recapture methods to estimate smolt abundance, and port and creel sampling of CWTs in mixed stock commercial and sport fisheries provides data to estimate marine harvest for both species. Juvenile salmon will be marked with adipose fin clips and a CWT in fall 2015 (Chinook juvenile salmon) and spring 2016 (Chinook and coho salmon smolt) as event 1 of the mark-recapture study. During event 2, adult Chinook salmon will be sampled for missing adipose fins, CWTs, and age, sex, and length (ASL) in Chilkat River fishwheels and drift gillnets, operated in the lower Chilkat River as part of a separate adult M-R project. Adult Chinook salmon will be also sampled for missing adipose fins, CWTs, and ASL during Chilkat River drainage spawning grounds to complete event 2 sampling. Coho salmon will also be sampled as adults during event 2 in the lower Chilkat River fishwheels. Age composition of Chinook salmon adults will be estimated by scale ageing techniques; age composition of coho salmon smolt and adults will also be estimated. The Alaska Department of Fish and Game uses these data to make local and regional management decisions. Chilkat Chinook salmon is a Pacific Salmon Commission exploitation rate and escapement indicator stock, and has recently been added to the base model of abundance indicator stocks for the Chinook Technical Committee, which influences coastwide management.

Key words: Chinook salmon, *Oncorhynchus tshawytscha,* coho salmon, *Oncorhynchus kisutch,*coded wire tag, mark-recapture, escapement, Chilkat River, Haines, Lynn Canal, marine harvest, marine survival, .

PURPOSE

The Chilkat River is considered the third or fourth largest producer of Chinook salmon in Southeast Alaska (McPherson et al. 2003). Chilkat River Chinook salmon is a Pacific Salmon Commission (PSC) exploitation rate and escapement indicator stock and contributes towards management of the Southeast Alaska sport fishery allocation in accordance with the Pacific Salmon Treaty (PST). The Chilkat River is also the second largest producer of coho salmon in Southeast Alaska (Shaul et al. 2008), and offers one of the largest coho salmon freshwater fisheries in Southeast Alaska (Jennings et al. 2011).

Stock assessment of Chilkat River Chinook and coho salmon includes full production estimates; the Chilkat River coded wire tag (CWT) project is an important component towards estimating smolt abundance, marine harvest in mixed-stock fisheries, and marine survival from smolt to adult. Coded wire tag studies have been conducted on the Chilkat River consistently since 2000. Smolt abundance along with harvest contributions have been estimated for Chilkat River Chinook salmon brood years 1998–2008, with brood years 2009–2012 in progress. Smolt abundance, marine harvest, and marine survival have been estimated for coho salmon outmigration years 1999–2013, with 2014 in progress.

Chilkat River Chinook salmon smolt abundance averaged 170,417 (SE = 42,239) for brood years (BY) 1999–2008, total return averaged 4,483 (SE = 508), marine harvest averaged 1,027 (SE = 197), and marine survival averaged 2.9% (SE = 0.7%). For emigration years 1999–2013, Chilkat River coho salmon smolt abundance averaged 1,259,342 (SE = 189,585), total return averaged

137,318 (SE = 15,943), marine harvest averaged 55,218 (SE = 5,870), and marine survival averaged 11.2% (SE = 2.2%).

This operational plan includes the study design for fall coded-wire tagging of Chinook juvenile salmon in the Chilkat River drainage, including the Tahini and Kelsall rivers and Chilkat River main channels during September and October 2015, as well as spring tagging of Chinook and coho salmon smolt during April and May 2016 in main channels of the Chilkat River.

BACKGROUND

The Chilkat River is a large glacial system that originates in British Columbia, Canada and traverses rugged mountainous terrain and terminates in Chilkat Inlet in northern Lynn Canal (Figure 1). The main channels and major tributaries comprise approximately 350 km of fluvial habitat in a watershed covering about 1,600 km² (Bugliosi 1988). The Chilkat River is the third or fourth largest producer of Chinook salmon (*Oncorhynchus tshawytscha*) (McPherson et al. 2003) and the second largest producer of coho salmon (*O. kisutch*) in Southeast Alaska (Shaul et al. 2008).

Chilkat Chinook salmon are harvested primarily in commercial troll (2004-2014 average 44%), commercial drift gillnet (23%), and Haines area sport (13%) fisheries, with smaller harvests occurring in Southeast Alaska (SEAK) sport fisheries (7%) and purse seine fisheries (3%). Haines area subsistence fisheries comprise 10% of the overall harvest (Table 1). From 1981 through 1992, the Chilkat River Chinook salmon escapement was monitored through peak survey counts on clearwater tributaries to the Chilkat River (Big Boulder Creek and Stonehouse Creek) as an index of abundance. Mark-recapture (M-R) experiments have been used to estimate the abundance of large Chinook salmon entering the Chilkat River since 1991. Comparisons of 1991 and 1992 M-R estimates to expanded Stonehouse Creek and Big Boulder Creek index counts showed that the expanded index counts grossly underestimated total Chilkat River abundance (Johnson et al. 1993).

Between 1991 through 2014, M-R estimates of inriver abundance of large Chinook salmon have ranged from 1,442 to 8,100 fish. Removing inriver subsistence harvest, escapement estimates have ranged from 1,435 to 8,089 fish during the same time period (Table 2). In 2003, the Department adopted an escapement goal range of 1,750–3,500 large Chinook salmon for the Chilkat River drainage, concurrent with the Board of Fisheries approving the Chilkat River and Lynn Canal King Salmon Fishery Management Plan (5 AAC 33.384). The plan uses an inriver abundance goal range of 1,850–3,600 large Chinook salmon upstream of the adult marking area, based on stock-recruit analysis and the size of the Chilkat River drainage (Ericksen and McPherson 2004). Since Chilkat River Chinook salmon inriver M-R studies were initiated in 1991, escapement estimates were below the lower bound of the goal range in four years: 2007, 2012, 2013, and 2014 (Chapell 2010, 2013b, *in prep a,* Elliott *in prep a-c*).

Coded wire tag studies of Chilkat River Chinook salmon have been conducted periodically since 1985, including a consistent time series from 1999 through 2014 (Table 3). Chinook harvest contributions have been estimated for the Tahini River BY's 1984 and 1985 (Johnson et al. 1993) and the Chilkat River BYs 1988, 1989, 1991, 1998, and 1999–2008 (Ericksen 1996, 1999; Ericksen and Chapell 2006b; Chapell 2009, 2010, 2012, 2013a-b, Elliott *in prep a-c*). These studies indicate that Chilkat River Chinook salmon rear primarily in the inside marine waters of northern Southeast Alaska, and that exploitation rates on this stock have ranged from 8% to 37% (Table 4). However, a 1991 study that compared logbook-recorded catch rates to fish ticketreported catches showed that the Chinook salmon harvest in the Lynn Canal commercial drift gill net fishery was grossly underreported, so estimated marine exploitation rates are most likely biased low (Ericksen and Marshall 1997). Stock assessment data will also be continuously updated by including estimates of fall juvenile abundance, smolt abundance, overwinter survival, marine survival, and exploitation rates provided by CWT studies.

The Chilkat River produces coho salmon harvested in Haines area recreational fisheries and supports one of the largest freshwater coho fisheries in the Southeast Alaska region, with an average annual harvest of 2,060 coho salmon from 2000 to 2009 (Jennings et al. 2004, 2006a-b, 2007, 2009; Walker et al. 2003; http://docushare.sf.adfg.state.ak.us/dsweb/View/Collection-222, accessed July 2011). The contribution of Chilkat River coho salmon to mixed stock commercial and sport marine fisheries is SEAK averaged 55,218 from 2000 to 2014 (Table 5). Escapement and harvest research conducted during the 1980's on coho salmon stocks in Lynn Canal suggest that these stocks were subjected to very high (> 85%) exploitation rates (Elliott and Kuntz 1988; Shaul et al. 1991); since CWT studies began in 1999 exploitation rate estimates have ranged from 17% to 65% (Table 5).

Chilkat River coho salmon smolt were tagged with CWT's intermittently from 1976 to 1984, and annually from 1999 to 2015 (Table 6). Most (97%) of the 9,318 coho salmon smolt tagged in 2015 (Table 6) will start entering the lower Chilkat River as adults in August 2016, where a proportion will be captured and sampled for CWTs, which produces the smolt abundance estimate for the 2015 emigrating class. Overall, the Chilkat River coho salmon CWT project allows for estimates of smolt emigration abundance, marine harvest by fishery, and smolt-to-adult survival (Table 5). Total marine harvest (commercial, sport, and subsistence fisheries) has ranged from 12,142 fish in 2007 to 128,466 fish in 2004. Most of the marine harvest occurs in the commercial troll fishery (54–68%) and the Lynn Canal drift gillnet fishery (26–54%). Marine exploitation has varied from 17% to 65% during 2000–2014 (Table 5). Commercial fishery management, weather conditions, and the price of coho salmon are the primary reasons for the fluctuation in marine exploitation.

The Chilkat River coho salmon total escapement, including ocean age-.0 fish, has been estimated each year since 1987 by expanding peak counts from index area foot surveys in four widely distributed streams: Spring Creek in the Tsirku River drainage, Kelsall River, Tahini River, and Clear Creek on the west side of Chilkat Inlet (Figure 2, Table 7). The total of all four index counts is expanded to estimate escapement, based on five past M-R experiments used to calibrate the index count. Mark-recapture projects were conducted in 1990 (estimate: 79,807 fish, SE = 9,980), 1998 (estimate: 50,758, SE = 10,698), 2002 (estimate: 205,429, SE = 31,165), 2003 (estimate: 134,340, SE = 15,070), and 2005 (estimate: 38,589, SE = 4,625) (Elliott 2009). Averaging the ratios of M-R estimates to the sum of concurrent peak index counts has produced an expansion factor of 33.6 (SE = 6.5). Mark-recapture studies must be repeated periodically to calibrate the expansion factor.

This operational plan covers sampling and estimation of smolt abundance and subsequent adult harvest by marking juvenile Chinook salmon with adipose fin clips and CWTs in fall 2015, and marking Chinook and coho salmon smolts in spring 2016. Marking coho salmon during the spring CWT project is funded separately outside of Chinook Salmon Research Initiative funds.

OBJECTIVES

1. Estimate the number of Chinook salmon smolt leaving the Chilkat River in spring 2016 such that the estimate is within 30% of the true value 90% of the time.
2. Estimate the marine harvest of Chilkat River Chinook salmon from the 2014 brood year (via recovery of adults with coded wire tags that emigrate as smolt in 2016) such that the estimate is within 35% of the true value 90% of the time.[1]
3. Estimate the number of coho salmon smolt leaving the Chilkat River in 2016, such that the estimate is within 40% of the true value 90% of the time.
4. Estimate the marine harvest of Chilkat River coho salmon in 2017 (via recovery of adults with coded wire tags that emigrate as smolt in 2016) such that the estimate is within 25% of the true value 90% of the time.[2]
5. Estimate the proportion of adult coho salmon returning to the Chilkat River in 2017 that were marked with coded wire tags in 2016, such that the estimate is within 5% of the true value 90% of the time..
6. Estimate the age composition of coho salmon smolt emigrating from the Chilkat River in 2016 such that the estimates are within 5% of the true values 90% of the time..
7. Estimate the age composition of adult coho salmon in the Chilkat River in 2017 such that the estimates are within 5% of the true values 90% of the time.

SECONDARY OBJECTIVES

1. Estimate the abundance of juvenile Chinook salmon rearing in the Chilkat River in fall 2015.
2. Estimate the mean length of Chilkat River juvenile Chinook salmon (in fall 2015) and the mean length of smolt emigrating in spring 2016.
3. Estimate the mean length-at-age of coho salmon smolt emigrating from the Chilkat River in 2016.

METHODS

Two-event M-R experiments will be used to estimate the abundance of juvenile Chilkat River Chinook salmon rearing in the Chilkat drainage in fall 2015, Chinook salmon smolt emigrating in spring 2016, and coho salmon smolt emigrating in spring 2016. Fish in M-R event 1 will be marked by removing the adipose fin and inserting a CWT in the nose cartilage. Marked fish will be sampled to estimate mean length and weight. Coho salmon smolt will be sampled to estimate freshwater age composition. For M-R event 2 sampling, adult Chinook and coho salmon will be sampled for missing adipose fins and CWT presence as they return to the Chilkat River in 2017 (coho salmon) and 2017–2021 (Chinook salmon). The harvest of Chinook and coho salmon will be estimated through the recovery of CWTs in randomly sampled fisheries.

Chilkat River Chinook salmon are almost all (>99%) yearling smolt, overwintering 1 year and emigrating as age-1. smolt (Olsen 1992). Therefore, Chinook juvenile salmon tagged in the fall

[1] Estimate will be derived from tag recoveries in marine fisheries and the Chilkat River from 2017 through 2021.

[2] Estimate will be derived from tag recoveries in marine fisheries and the Chilkat River in 2017.

of year t+1, and smolt tagged in the spring of year t+2, are from BY t. Adult Chinook salmon return to the river over a span of five years, beginning with age-1.1 "jacks" in year t+3 and ending with age-1.5 fish in year t+7. For example, Chinook salmon tagged with CWTs in the fall of 2015 (juvenile) and spring 2016 (smolt), both from BY 2014, will return in 2017 (age-1.1 "jacks") though 2021 (age-1.5 fish).

Coho salmon returning to the Chilkat River belong primarily to 2 age classes: age 1.1 (1998–2010 average 76%), and age 2.1 (1998–2010 average 22%). The remaining age classes are age-1.0 and age-2.0 "jacks" that have composed 3% of the escapement over the same time period. Because the majority of coho salmon are 1-ocean year rearing fish, coho smolt tagged with CWTs in 2016, from BYs 2013 and 2014, will return primarily in 2017.

SMOLT AND JUVENILE TAGGING

Fall 2015 - Chinook Juvenile Salmon Tagging

To estimate juvenile Chinook abundance, a range of 80–100 baited minnow traps will be set and retrieved per day in the Tahini River, Kelsall River, and Chilkat River main channels from the Kelsall River confluence downstream to Haines Highway milepost (MP) 10. Captured fish will be sorted, and only juvenile Chinook salmon will be retained for tagging. All trapping locations will be recorded with global positioning system (GPS) coordinates and juvenile Chinook salmon catches will be recorded by location. All juvenile Chinook salmon caught in traps will be transported to a central tagging location. Once at the tagging site, all healthy juvenile Chinook salmon ≥50 mm fork length (FL) will have their adipose fin removed and will be tagged with a 1.1 mm CWT (see Data Collection for details of processing). All Chinook salmon tagged will be checked the day after tagging for tag retention and released in the same stream as captured. One code of 10,000 tags will be used until exhausted; additional codes will be used for every subsequent 10,000 fish tagged during the fall project.

The Tahini and Kelsall rivers trapping areas align closely with results of 1991, 1992, and 2005 radio telemetry studies (Johnson et al. 1992, 1993; Ericksen and Chapell 2006b), which indicated that 85–92% of the Chinook salmon entering the Chilkat River spawn in these two drainages.

Tagging operations will begin September 16 on the Tahini River, where a crew of four technicians will trap and tag juvenile Chinook salmon for up to 10 days, depending on river conditions and catch rates. If catch rates are lower than expected in traditional trapping areas, traps will be set over a wider area in an exploratory fashion to locate concentrations of rearing fish. In efforts to maximize catch rates, traps will be moved consistently when catch rates drop.

The Kelsall River has been the biggest producer of juvenile Chinook salmon in most years (Table 3) and will continue to be the major focus of effort in fall 2015. Trapping efforts on the Kelsall River will commence October 1 and will continue for up to 14 days, or until all trapping areas are exhausted.

After leaving the Kelsall River, trapping efforts will move to Chilkat River main channels. Traps will be set primarily between MP 13 and MP 19, and in the section between MP 24 and the Kelsall River confluence. The Chilkat River portion of the project does not require a field camp, as the crew is based from the Haines office.

Spring 2016 - Chinook and Coho Smolt Tagging

From April 3 through May 14, 2016, a minimum of 80 and up to 100 baited minnow traps will be set and retrieved daily in main channels of the lower Chilkat River, MP 10–21, in an effort to maximize Chinook salmon smolt catches. All coho salmon smolt ≥75 mm FL captured in the process will also be tagged. Gear will be set in Chinook salmon habitat sites that provide the best chance of capturing a representative sample of smolt from several tributaries of the Chilkat River. Global positioning system coordinates and Chinook and coho salmon smolt catches will be recorded at each tagging site. Two trap lines will be checked at least once per day by two teams of 2 technicians each. If time permits, traps that produced the greatest catches during the first check will be checked twice. Short (40') beach seines will also be used concurrently with minnow traps to capture additional Chinook salmon smolt.

Compared to spring CWT efforts in years 2001–2012, the spring 2016 effort will be shorter in duration but similar to 2013-2015. We will utilize a minimum of 41 trapping days, beginning in early April and running until mid-May. The expected number of valid CWTs released is based on an average daily trap total (90 traps, Appendix A1). The estimated number of Chinook salmon smolt based on 2013-2015 CPUE is 4,045 fish, and estimated coho salmon smolt marked is 10,258. Only the most recent CPUE is used because of the shift in project focus and duration compared to 2000-2012. Average juvenile Chinook salmon CPUE in 2013-2015 was 1.1 fish per trap, and average juvenile coho salmon CPUE was 2.8 fish per trap.

All target species caught in traps will be transported to a central tagging location. Every second day, depending on the number of smolts caught, collected fish will be sorted by species and size. All healthy Chinook ≥50 mm and coho ≥75 mm FL salmon captured will be adipose fin-clipped and implanted in the snout with a 1.1 mm CWT (see Data Collection for details of processing). Tagging every second day will increase capture rates by allowing for more time to seek out productive trapping areas. A Northwest Marine Technology Mark IV[3] tag injector will be dedicated to tagging Chinook salmon with a unique code. Spools of coded wire will be changed only when exhausted.

Coho salmon smolt will be sorted into 3 size categories: small (≥75 mm and <85 mm), medium (≥85 and <100 mm), and large (≥100 mm). A tag injector will be dedicated to tagging coho salmon. A different size head mold (small, medium, large) will be used with each size group to achieve optimal CWT placement and retention. Two unique tag codes will be assigned by size: small fish will receive one code, and medium and large fish (all coho salmon ≥85 mm) will receive the other code. Tagging each size group (small vs. medium/large) of coho salmon smolt with unique tag codes will allow for detection of differential recovery rates as adults. An alternate smolt population estimator discussed in Data Analysis can eliminate bias created in disproportionate tagging of coho salmon smolt.

[3] Northwest Marine Technology, 976 Ben Nevis Loop, Shaw Island, WA, 98286

SAMPLING ADULT COHO AND CHINOOK SALMON TO ESTIMATE SMOLT AND FALL JUVENILE (CHINOOK) ABUNDANCE

Division of Commercial Fisheries (CF) personnel will capture adult coho salmon in two fish wheels along the Chilkat River, adjacent to the Haines Highway between MP 7 and 9, operated annually from approximately June 10 to October 15. Data collected in previous years indicates that 97% of the immigrating coho salmon will be caught during this time period. Fish wheels will operate continuously except when stopped for maintenance.

Proportional sampling of coho salmon in the lower Chilkat River fish wheels (Figure 2) will allow estimation of the marked fraction used to calculate smolt abundance and adult harvest. In 2015, we expect the return of coho salmon that emigrated in spring 2014, when 8,661 fish were marked with CWTs and released. Calculation of the mark fraction includes all 1-ocean coho salmon that are inspected for missing adipose fins. Coho salmon will be carefully removed from the fish wheel holding pen, and placed into a trough filled with water. All newly captured coho salmon will be sampled for length from mid eye to fork of tail (MEF), sex, and missing adipose fins. Data will be recorded on the Alaska Department of Fish and Game (ADF&G) Adult Salmon Age-Length form version 3.0 (ASAL, Figures 3 and 4). Fish that are missing their adipose fins will be sacrificed for recovery of the CWT. Heads will be removed and marked with a numbered plastic cinch strap; the strap number will be recorded on the ASAL form and a CWT recovery form. To prevent double sampling, all coho salmon captured in the lower river will be given a lower left operculum punch that will be recognized upon recapture.

To systematically subsample the coho salmon immigration for age composition, scales will be collected at a rate of approximately 1 out of 3 fish, and in addition, from all fish with missing adipose fins. The first 13 of 40 fish, regardless of adipose fin clip status, will be recorded on an ASAL labeled *001* (Figure 3). The associated scale cards will be numbered sequentially, with the first 10 scales on card *001*, and the remaining 3 scale samples, plus any additional scales from adipose-finclipped fish, on card *002*. The fish numbered 14 or higher (CWT fish only) will not be used for calculating age composition, but for determination of recovery rates and freshwater ages of the 2 different coho salmon smolt tagging groups. The remaining 27 out of 40 fish will be sampled for sex and length only, and their data will be recorded on ASAL form labeled *002A* (Figure 4). For subsequent batches of up to 40 fish, the first 13 fish will again be sampled for sex, length and scales, their scales placed on cards *003* and *004*, and their ASAL form labeled *004*. The data (sex and length only) for the remaining 27 of 40 fish will be recorded on ASAL form *004A*. Each new sampling day will start with a new set of ASAL forms scale cards, with numbering continued sequentially. This numbering system will assist CF staff in entering the sex, length, and age data into the CF database.

The scale sampling procedure includes removing 5 scales from the left side of each sampled fish (right side if left-side scales are regenerated) along a line 2 to 4 scale rows above the lateral line between the posterior insertion of the dorsal fin and anterior insertion of the anal fin (Scarnecchia 1979). Scales will be carefully cleaned and placed on gum cards at the rate of one fish per column (i.e., scales from fish #1 will be placed over 1, 11, 21, and 31 on the gum card, and the fifth scale will be placed in the blank space just below 31). Scales need to be upright (posterior down) with the rough (convex) side out. Obvious regenerated scales will be discarded and new scales selected. When placing scales, room will be left at the top middle portion of the card so a label can be affixed later. Scale cards will be kept as dry as possible to prevent gum from running and obscuring the scale ridges, and will be completely labeled including the last names of each sampler. A triacetate impression of the scales (30 seconds at 3,500 lb/in^2, at a temperature of 97°C) will be used for age determination. Scales will be read for age using protocols in Mosher (1969) and the CF scale-aging group.

Escapement sampling of adult Chinook salmon in the Chilkat River is detailed in a separate operational plan covering the use of fish wheels and drift gillnets in the lower river (event 1) and various gear types on the spawning grounds (event 2) to capture and sample adults (Elliott et al. 2015). The details relevant to the objectives of this plan are as follows: all adult Chinook salmon captured in the lower river and on the spawning grounds will be inspected for missing adipose fins and sampled for age, sex, and length. Heads will be collected (for CWTs) from Chinook salmon less than 660 mm MEF (primarily age-1.1 and-1.2 males). Heads will also be taken from fish that show a negative wand detector result for a head CWT to confirm the head CWT loss rate. Heads will also be taken from spawned-out fish and carcasses of all sizes on the spawning grounds (61% of the large fish sampled in 1991–2014). These criteria for sacrificing fish will minimize the impact of sampling on Chinook salmon spawning production.

SAMPLE SIZES

Smolt and Juvenile Abundance

Chinook Salmon

Returning Chinook salmon in the Chilkat River will be inspected for marks (missing adipose fins) in 2017 through 2021 (ages 1.1 to 1.5) during annual adult M-R studies, as detailed in Elliott et al. (2015). Lower Chilkat River capture gear used for event 1 marking and sampling includes drift gillnets operated by Division of Sport Fish (SF), and fish wheels operated by CF. Spawning Chinook salmon will also be inspected during event 2 in several spawning locations using various capture gear types. Inriver abundance of ocean-age-2 and older Chinook salmon in recent brood years (1999–2008) has averaged 3,456 fish (SE = 461; Table 4). The harvest rate of Chilkat River Chinook salmon has averaged 24.5% (SE = 4.3%) under Southeast Alaska fishing regulations, which averages 1,027 fish per year in all marine fisheries, including commercial, sport, and subsistence (Table 4). Assuming average smolt abundance, we anticipate 170,417 Chinook salmon smolt will leave the Chilkat River in 2016. Assuming average overwinter survival (35.9%, Table 4), we anticipate that 474,912 Chinook juvenile salmon will be rearing in the Chilkat River drainage during the fall of 2015. If the tagging goal of 25,000 Chinook juvenile salmon is reached in fall 2015, 5.3% of the juvenile population will be marked. This 25,000 tagging goal has been met in 9 of the last 15 years (2000–2014, Table 3), so the goal is likely to be attained. Approximately 8,971 (35.9% x 25,000) of these marked juvenile Chinook salmon should survive to emigrate as smolt. Using anticipated spring CPUE from 2013-2015 (Appendix A1), an additional 4,045 Chinook salmon smolt will be coded-wire tagged in spring 2016, so we can reasonably expect 13,016 from an average smolt population of 170,417 to be marked with CWTs (marked fraction 7.6%, Appendix A2).

From 1994 to 2014, an average of 948 immigrating Chinook salmon (306 in the lower river and 642 on spawning grounds) have been inspected annually for missing adipose fins. In efforts to conserve the small stock, not all fish missing adipose fins will be sacrificed to recover CWTs (Objectives 1 and 2). Heads will be taken only from fish <660 mm MEF and from post spawners and carcasses, so samples sizes for a BY are expected to be 231 age-1.1 and 1.2 (average number of fish <660mm MEF sampled for adipose fin clips, 1994–2014) and 385 adults (≥age-1.3, average number of post spawners or carcasses ≥660mm MEF sampled for adipose fin clips, 1994–2014), or 616 valid samples. Because an escapement sample of 396 fish is needed to meet the criteria for Objective 1 (Robson and Regier (1964), smolt emigration of 170,417 with 13,016 marked, no lost CWTs; alpha = 0.10; d = 0.30), it is reasonable to expect meeting the criteria in Objective 1.

Coho salmon

Using 2013-2015 CPUE and the average of traps deployed for 41 days of trapping (April 3–May 13, Appendix A1), 10,258 coho salmon smolt will be coded-wire tagged and released in 2016. Under the current study design, therefore, it is unlikely that the number of coho salmon smolt tagged and released will meet or exceed the 2001–2015 average of 21,919 fish (Table 6).

Returning adult coho salmon will be inspected for missing adipose fins in 2017 in Chilkat River fish wheels operated by CF. The fraction used to estimate smolt abundance is the proportion of 1-ocean coho salmon missing adipose fins (θ_{smolt}). We anticipate capturing and sampling about 2,516 returning 1-ocean coho salmon in the fish wheels (average number inspected 2000–2014). Using the model of Robson and Regier (1964) with an assumed population size of 1,259,342 (Table 5) and 10,258 marks released, a sample of 2,474 adults is needed to meet precision criteria (Objective 3, assuming alpha = 0.10, d = 0.40). It is expected that 19 of those fish would have adipose fin clips. Because the average fish wheel number inspected is greater than this sampling goal, the criterion is expected to be met. The field sampling design has resulted in the 90% confidence interval being within 40% of the estimate in all 15 outmigration years 1999–2013 (Table 5); the goal remains to mark and inspect as many fish as possible.

AGE COMPOSITION, MEAN LENGTH, AND MARKED FRACTION

The age composition, mean length-at-age, and marked fraction of immigrating Chinook salmon in 2017–2021 will be estimated as detailed in a separate operational plan for the annual SF adult stock assessment project (Elliott et al. 2015).

Age composition and mean length-at-age of immigrating coho salmon will be estimated from a systematically drawn sample of the fish caught in the fish wheels. Based on procedures in Thompson (2002) for a 4-age-class population and an average estimated escapement of 74,634, with alpha = 0.10 and d = 0.05, 448 samples are needed. In an exercise to numerically demonstrate how sample sizes are derived, the proportions representing 1.0- and 2.0-age fish were constrained at historical proportions of 0.03 and 0.01, respectively, and the highest variability scenario when proportions between age 1.1 and 2.1 coho salmon are almost equal, was investigated (Figure 5). This model, based on Thompson (2002), produces a sample size maximum that, when data loss is accounted for, is commensurate with the required sample size (426) for a multinomial estimation with the given precision criteria.

Because on average 90% of adult scale samples are readable, the highest possible sample size is 448 (d = 0.05, alpha = 0.10, n = 74,634, data loss = 10%). The average fish wheel catch of 1-ocean coho salmon from 2000 to 2014 is 2,516 fish. To ensure that this sample goal is met, <u>every third fish caught (2,516/3 = 838) will be sampled for scales</u>. Fish wheel catches have shown considerable variability from year to year; even though the projected number sampled greatly exceeds the requirement, in low catch years sampling every third fish should come close to meeting the goal. Since coho salmon sampling was started in the Chilkat River, the lowest proportion of age-1.1 fish has been around 0.70, requiring fewer than 448 samples to meet

Objective 7. As a result, 838 fish sampled should be ample to meet Objective 7 criteria. Objective 5 criteria will also be achieved, based on procedures in Thompson (2002), because only 34 fish are required to estimate a binomial proportion to within 0.05 of the true value 90% of the time (d = 0.05, alpha = 0.10, p = 0.030 (the highest theta for this project since 2000), n = 74,634, data loss = 10%). The estimates should be unbiased because, even if the sampling gear is size selective, the differences in age composition for coho salmon in SEAK are exclusively related to differences in freshwater age (except for a small number of "jacks"), and there is no relationship between freshwater age and the size of adult coho salmon.

Age composition of coho salmon smolt will be estimated from a systematically drawn sample of fish caught in the minnow traps. Based on the procedures in Thompson (2002), 285 samples are necessary to estimate binomial proportions (d = 0.05, alpha = 0.10, p = 0.5, N = 1,259,342, data loss = 5%) and satisfy Objective 6 criteria; this sample will also be sufficient to estimate mean length-at-age and weight in our secondary objectives, for which we have no precision criteria. If we tag 10,258 smolt as anticipated and systematically sample every 25th coho salmon smolt ≥75 mm FL, the resulting sample of 410 is larger than required to meet objective 6 criteria.

We will systematically sample every 100th Chinook juvenile salmon ≥50 mm FL during fall 2016, and every 20th Chinook salmon smolt during spring 2016 for length and weight (BY 2013 mean = 73.2 mm and 4.5 g).

HARVEST OF CHINOOK SALMON FROM THE 2014 BROOD YEAR

Recovery of coded-wire tagged Chinook salmon in the various fisheries in 2017–2021 (to sample age-1.1 to age-1.5 fish) will be used to estimate the total marine harvest of Chinook salmon from the Chilkat River from BY 2014. To meet the criterion in Objective 2 (90% relative precision = ±35%), approximately 10,500 Chinook salmon smolt from BY 2014 emigrating in 2016 need to be marked with CWTs according to procedures in Bernard et al. 1998 (see example in the next paragraph and Appendix A3). Because we expect 13,016 Chinook salmon smolt to be marked, the objective criteria should be met. The sample size calculation is based on historical sampling rates in the following fisheries where Chilkat CWTs are encountered: 35% in winter troll, 54% in spring troll, 22% in summer troll, 43% in drift gillnet, 28% in purse seine, and 41% in Southeast Alaska sport. These sampling rates are based on ADF&G Mark, Tag, and Age lab sampling data from 2004-2014. Overall, the sampling rate is 44% for all mixed stock fisheries combined. Brood year 2014 should produce an average of 170,417 smolt leaving the Chilkat River in 2016, which should survive at 2.9% during the marine rearing phase. While rearing, CWT recoveries and expansions (Bernard and Clark 1996) from BY2014 should estimate exploitation of 17.4% in mixed stock fisheries, 2.4% in the Haines sport fishery, and the 1.1% in the Chilkat Inlet subsistence fishery, for an overall exploitation rate of 20.9% (Appendix A2).

A simulated data set to anticipate harvest from the 2014 Chilkat Chinook brood, based on the above assumptions and past recoveries of Chilkat River CWTs from mixed stock fisheries in 2004-2014, suggests that Objective 2 will likely be met (Appendix A3). We anticipate that under average fishing regimes, 6% of the mixed stock Chilkat Chinook salmon harvest will occur in the winter troll fishery, 23% in spring troll, 11% in summer troll, 42% in drift gillnet, 5% in purse seine, and 12% in Southeast Alaska sport fisheries (Appendix A2). Using a 44% overall sampling rate in marine fisheries, we expect that 65 Coded-wire tagged fish will be recovered, of which 27 are anticipated to be random recoveries of coded-wire tagged Chilkat River Chinook salmon. Probabilities for recovery of a Chilkat River CWT (represented by $\hat{p}$ CWT in Appendix A3) at different ages from different fisheries were based on recoveries of Chilkat River CWTs from 2004-2014. In efforts to represent all principal fisheries, including gear, area, and time, for Chilkat CWT recoveries, there are numerous instances when the calculated value for m_i is less than one. There are, therefore, several low probabilities in this exercise for recovery of a Chilkat River Chinook salmon CWT. Methodology in Bernard et al. (1998) was used to estimate the chance of missing harvest in fisheries. Reported harvests in each stratum represent the cumulative catch and harvest estimates for each occurrence of a Chilkat CWT during the 2004-2014 time period. The average anticipated probability of recovering a CWT from each time-area-fishery stratum is 23%, and the probability of getting CWTs in all strata (the product of the individual stratum probabilities) is less than 1%. Despite this low probability, harvests in most individual strata are small, and the loss of some harvest estimates will not be critical. Given the significant current fishery sampling effort and 7.6% average marked fraction (Table 4), there is little that can be done to improve the situation at this time. Overall, assuming that every fishery encountered in the 2004-2014 time period has representation for BY2014, relative precision of the estimated harvest is 15.4%, meeting Objective 2 precision criteria (Appendix A3). For marine harvest estimates for brood years 1999-2008 the average coefficient of variation is 20% and the 90% confidence interval is within 31.6% of the estimate. This precision should enable objective 2 to be achieved.

Protocols for the collection of data from adult Chinook salmon at the ADF&G fish wheels and drift gillnets and in the marine commercial fishery can be found in operational plans developed by SF and CF for these projects. The CF operational plans can be obtained from the CF Area Management Biologist in Haines.

HARVEST OF COHO SALMON IN 2017

Almost all coho salmon smolt tagged in 2016 that avoid mortality will emigrate to sea, mature, and return to the Chilkat River drainage to spawn in 2017. Some returning adults will be harvested in marine sport and commercial fisheries, which are sampled for missing adipose fins and presence of a CWT by the CF port sampling program and SF creel sampling program. Recoveries of CWTs from Chilkat River coho salmon tagged in 2016 will be used to estimate that cohort's contribution to the sampled fisheries in 2017 (Objective 4; Bernard and Clark 1996).

Historical data from port sampling efforts from 2000 through 2014, along with smolt tagging data for these cohorts, was used to calculate average recovery probabilities (π_i) of tagged adults bound for the Chilkat River by sport and commercial fishery recovery strata (Bernard et al. 1998). A simulation based on these recovery probabilities was then used to anticipate precision of the contribution estimate to the marine commercial and recreational fisheries for 2016. The simulation (Appendix A4) assumes an average smolt abundance of 1,259,342, the number of valid tagged coho salmon smolt of 10,258, an average (2000–2014) harvest of 1.4 million fish of mixed stock, typical port sampling efforts by strata, and an average adult escapement sample of 2,516 1-ocean adults in 2017. These assumptions result in an anticipated fraction of valid tags (θ_{marine}) of 0.81% and an estimated recovery of 106 coded-wire tagged coho salmon bound for the Chilkat River in 2017 (Appendix A4). The estimate of relative precision for the 2017 harvest estimate is ±17.1% for a 90% confidence interval. This precision should enable objective 4 to be achieved. Methodology in Bernard et al. (1998) was used to estimate the chance of missing harvest in fisheries. Anticipated recoveries of fish bound for the Chilkat River in most sport and seine fisheries strata are small (less than 1 tag), which leads to relatively small probabilities of recovering tags in these strata (Appendix A4). However, the total contribution from *all* sport and seine strata is 3% of the total (2% from sport, 1% from seine strata). Thus, missing harvest from a significant fraction of these strata does not lead to a significant bias in the total contribution estimate. Excluding strata where <1 tag recovery is expected suggests the probability of recovering CWTs in *all* other strata (the product of all individual stratum probabilities) is about 33%. Furthermore, the probability of recovering CWTs in all of the major strata (expected tag recovery >2, including troll and District 115 gillnet) is 96%.

DATA COLLECTION

SMOLT ABUNDANCE

All captured coho salmon smolt ≥75 mm FL (spring 2016) and all Chinook salmon ≥50 mm FL (fall 2015 and spring 2016) without CWTs will be tranquilized with a buffered MS 222 solution, tagged with a CWT following procedures described in Koerner (1977), marked with an adipose fin clip, and released. All tagged fish will be held overnight to test for mortality and 100 of each species will be tested for retention of their tags. Any smolts captured that have missing adipose fins prior to tagging will be passed through a magnetic tag detector and the presence or absence of a CWT will be recorded. In addition, the tag location of all Chinook salmon will be verified with a wand detector.

A short section of each spool of coded wire will be taped to the SPORT FISH DIVISION SALMON SMOLT CWT DAILY LOG form (Appendix B1) the first day of tagging with a new tag code. In addition, a short section of the beginning and ending wire for each location (i.e., Tahini River, Kelsall River, and Chilkat River) will be taped to the CWT Daily Log. A new form will be started for each tagging day. All tag and recapture data will be recorded daily on the CWT Daily Log form. The field crews will record tagging site GPS coordinates in field notebooks following the instructions found in Appendix C1. The crews will record detailed trapping information in field notebooks following the protocols in Appendix B2. Catch, tagging, release, and recapture data for each day's operation will be summarized on the MINNOW TRAP SUMMARY FORM, an example of which is found in Appendix B3. Daily procedures follow.

Fall 2015 Chinook Juvenile Tagging

1. Record location, date, and species on the SALMON SMOLT CWT DAILY LOG.
2. Record water and air temperature (Min-Max) to nearest 1^{o}C, and water depth to the nearest cm on the MINNOW TRAP SUMMARY FORM. Data should be collected at 0900 each day.
3. At 0830–0900 hrs mix the fish in the holding net pen for each tag code and check 100 that are representative for tag retention and record on the SALMON SMOLT CWT DAILY LOG. If tag retention is 98/100 or greater, empty the net pen and count and record mortalities, transport to release site, and release all fish. If tag retention is 97/100 or less, reprocess the entire batch and retag all fish that test negative.
4. Check minnow traps and transport to tagging site. Sort Chinook salmon ≥50 mm FL from other species (coho salmon are not tagged). Inspect each live fish and count the number with adipose clips and record the number under "Recaptures" on the SALMON SMOLT CWT DAILY LOG. Check all recaptures for tag retention, record results, and release all recaptures with CWTs. Retag all recaptures without CWTs.

5. Give all live untagged fish a CWT and pass each through the tag detector. If rejected by the detector, retag and tally all retags on a hand counter. Write the beginning and ending machine numbers on the SALMON SMOLT CWT DAILY LOG and record retags, erroneous tags (misses, tagged fingers, etc), and practice tags. Show your calculations for the number of tags used.
6. Systematically select every 100th Chinook salmon from combined catches and measure for FL to nearest mm and record all data, including gear type and location on the CHILKAT RIVER FALL CHINOOK SAMPLING FORM (Appendix B4).

Spring 2016 Chinook and Coho Smolt Tagging

1. Record location, date, and species on the SALMON SMOLT CWT DAILY LOG.
2. Record water and air temperature (Min-Max) to nearest 1^{o}C, and water depth to the nearest cm on the MINNOW TRAP SUMMARY FORM. Data should be collected at 0900 each day.
3. At 0830–0900 hrs mix the fish in the holding net pen for each tag code and check a representative sample of 100 coho smolt for tag retention and record on the SALMON SMOLT CWT DAILY LOG. If tag retention is 98/100 or greater, empty the net pen and count and record mortalities, transport to release site, and release all fish. If tag retention is 97/100 or less, reprocess the entire batch and retag all fish that test negative. The same procedures apply to Chinook salmon smolt. The snout of each fish will be will be scanned by swiping the marked side of the CWT detector wand (Vander Haegen et al. 2002) in contact with the snout at a rate of 2–3 m per second.
4. Check minnow traps and transport catch to tagging site. Sort coho salmon ≥75 mm FL and Chinook salmon ≥50 mm FL from smaller fish and other species. Inspect each live fish and count the number with adipose clips and record the number under "Recaptures" on the SALMON SMOLT CWT DAILY LOG. Check all recaptures for tag retention and tag location (for Chinook salmon smolt), record results, and release all recaptures with CWTs. Retag recaptures without CWTs.
5. Give all live untagged fish a CWT and pass each through the tag detector. If rejected by the detector, retag and tally all retags on a hand counter. Write the beginning and ending machine numbers on the SALMON SMOLT CWT DAILY LOG and record retags, erroneous tags (misses, tagged fingers, etc), and practice tags. Show your calculations for the number of tags used.
6. Systematically select every 25th coho salmon and measure for FL to nearest mm, weigh to nearest 0.1 g, sample for scales, and record all data, including gear type and location on the CHILKAT RIVER COHO SALMON AWL FORM (Appendix B5).
7. Systematically select every 20th Chinook salmon from combined catches and measure for FL to nearest mm and record all data, including gear type and location (Appendix B4).

At the end of the fall 2015 and spring 2016 tagging seasons, daily tagging information will be entered into CWT Online Release Entry software program (http://www.taglab.org), which will estimate the number of smolts that had retained CWTs and will submit the tag release information to the Tag Lab (Appendix B6). A 5 cm length of each code wire used will be attached to a TAG CODE VERIFICATION FORM and mailed to the Tag Lab for code verification.

For coho salmon smolt sampled for length, weight and scales, remove 12 to 15 scales from the preferred area (Scarnecchia 1979) on the left side of the coho salmon smolt. Sandwich scales from up to 4 fish between two 25 x 75 mm microscope slides, and tape the slides together with transparent tape. Write the length of each fish on the frosted portion of the bottom slide in accordance with the position of the scales on the slide (Figure 6). Instructions to improve our ability to read scales (as determined by Sue Millard, ADF&G-SF, retired, through experience) are:

1. Don't tape over any scales,
2. Make sure scales are placed and remain in the designated area for each fish,
3. Always number each slide at the top,
4. Always put your initials under the slide number,
5. Spread scales out so they don't contact one another and align them as shown in Figure 6,
6. Remember to clean the scalpel of scales between samples.

Once Chilkat River Chinook salmon from BY 2014 have been captured, implanted with CWTs, marked with adipose fin clips, and released during the two tagging projects (fall 2015 and spring 2016), monitoring and recovery of these tags begins and continues over a 5 year period. Between 2017 and 2021, ADF&G will sample landings from commercial, sport and subsistence fisheries throughout Southeast Alaska and Yakutat for adipose fin clips and CWTs. The sample goal will be to inspect at least 20% of the total catch of Chinook salmon for missing adipose fins. Heads from fish missing their adipose fin will be sent to ADF&G's Juneau Tag Lab where CWTs will be removed and decoded. The annual ADF&G port sampling manual (*Coded wire tag sampling program detailed sampling instructions, commercial fisheries sampling*; located at Alaska Department of Fish and Game, Division of Commercial Fisheries, 802 3rd Street, Douglas, Alaska) provides a detailed explanation of commercial catch sampling procedures and logistics.

The number of BY 2014 Chilkat River Chinook salmon CWTs recovered 2017–2021 in all marine fisheries (commercial, sport, and subsistence) will be compiled by release group, i.e. fall 2015 or spring 2016, which is determined by the specific tag code from successfully read CWTs.

In addition to marine fisheries sampling, heads will also be collected from Chinook salmon with missing adipose fins during Chilkat River escapement sampling from 2017 through 2021. Escapement sampling is conducted annually in the Chilkat River drainage to estimate inriver abundance. Heads will not be collected from large (≥660 mm FL) fish in pre-spawning condition. The brood year of adipose-finclipped fish whose heads are not taken will be determined from scale age samples. All adipose finclipped fish will be examined with a handheld wand CWT detector (Vander Haegen et al. 2002) to determine presence/absence of a CWT. Heads from fish with missing adipose fins that do not indicate presence of a CWT will be collected to detect for tag loss.

DATA REDUCTION

It is the responsibility of the field crew leader to ensure accurate records are maintained for all data collected on a daily basis (e.g., sampling rates for age and length, correct secondary marks are applied, etc). The field crew leader will also ensure data collections (such as samplers initials, environmental data, fish length and condition, tag codes applied, etc.) are complete and methods (such as FL measurements, scale collection procedures, head mold sizes, etc.) are correctly implemented.

Data will be inspected daily for errors such as incorrect dates, transposed nonsensical lengths (210 mm when the fish was actually 120 mm), transposed or nonsensical tag numbers, incorrect tagging totals, CWT tagging lengths less than prescribed guidelines, etc. Data forms will be kept up to date at all times. Scale slides will be checked to insure that scales are clean and mounted correctly; the slides are correctly labeled, and samples are matched up with the corresponding data form. Data will be sent to the project biologist weekly, where they will be re-inspected for accuracy and compliance with sampling procedures. The project biologist will keep field data updated in Microsoft Excel™ while it is collected, in season, and produce weekly reports to other management biologists in Southeast Alaska. Ages from scale samples will be estimated in the scale aging lab in Douglas. Scale ages will be entered into the spreadsheet files. When all input is complete, data lists will be obtained and checked against the original field data.

When the final reports are complete, electronic copies of the data, along with a data map, will be sent to Research and Technical Services (RTS) for archiving. The data map will include a description of the electronic files contained in the data archive, and where copies of any associated data are to be archived, if not in RTS. After the daily CWT tagging, retention, and overnight mortality data have been entered using the CWT Online Release Entry program, the Tag Lab will maintain a permanent database of juvenile and smolt releases and will share this data with the Pacific States Marine Fisheries Commission.

DATA ANALYSIS

SMOLT AND FALL JUVENILE ABUNDANCE

Chinook Salmon

A statistical model will be fit to the BY 2014 data to obtain estimates of the number of BY 2014 juveniles rearing in the Chilkat River in fall 2015 ($\boldsymbol{N_{JUVENILE}}$), the overwinter survival to spring 2016 (ϕ_1), and the number of smolt outmigrating in 2016 ($\boldsymbol{N_{SMOLT}}$).

We will use a form of the Petersen estimator (Seber 1982) to obtain estimates of the number of BY 2014 juveniles rearing in the Chilkat River in fall 2015 ($N_{JUVENILE}$) and the number of smolt emigrating in 2016 (N_{SMOLT}):

$$\hat{N}_{JUVENILE} = (M_{JUVENILE} \text{ x } C) / \hat{R}_{JUVENILE} \tag{1}$$

and

$$\hat{N}_{SMOLT} = (M_{SMOLT} \text{ x } C) / \hat{R}_{SMOLT} \tag{2}$$

where:

$M_{JUVENILE}$ = number of CWTs applied to Chinook juvenile salmon marked during fall 2015,

M_{SMOLT} = number of CWTs applied to Chinook salmon smolt marked during spring 2016,

$C = R_1 + R_2 + R_3 + R_4$ = the total number of BY 2014 Chinook salmon examined for adipose fin clips in the Chilkat River in 2017–2021,

R_1 = the number of fall 2015 CWTs decoded from adipose-clipped fish in the Chilkat River,

R_2 = the number of spring 2016 CWTs decoded from adipose-clipped fish in the Chilkat River,

R_3 = the number of adipose-clipped fish in the Chilkat River whose CWTs were not decoded because the head was not taken, the head was lost, or the tag was lost, and

R_4 = the number of fish without adipose fin clips in the Chilkat River.

In order to estimate $\hat{R}_{JUVENILE}$ and $\hat{R}_{SMOLT,}$ we needed to estimate the proportion ρ of all adipose-clipped fish in the BY 2014 population with decoded CWTs using:

$$\hat{\rho} = R_{VTOT} / (R_1 + R_2 + R_3) \tag{3}$$

where

$$R_{VTOT} = R_1 + R_2. \tag{4}$$

We will then estimate the number of fall 2015-marked adipose-clipped fish in C using:

$$\hat{R}_{JUVENILE} = R_{VTOT} * \left[\frac{(R_1 + m_{FALL})}{(R_{VTOT} + m)} \right] \Big/ \hat{\rho} \tag{5}$$

where:

m = number of BY 2014 Chilkat Chinook CWTs recovered in marine fisheries, and

m_{FALL} = the CWTs from m that were fall 2015 CWTs.

The number of spring 2016-marked adipose-clipped fish in C will be estimated using:

$$\hat{R}_{SMOLT} = R_{VTOT} * \left\{ 1 - \left[\frac{(R_1 + m_{FALL})}{(R_{VTOT} + m)} \right] \right\} \Big/ \hat{\rho}\,. \tag{6}$$

Equations (5) and (6) make use of marine data in estimating the number of 2015- and 2016-marked adipose- clipped fish. It should be noted if the ratio of marine recoveries of CWTs is much different than that of inriver ratio of CWTs, e.g. due to small sample sizes, ambiguous results may ensue. In an extreme case where marine proportions were much different and with more weight ($m >> R_{VTOT}$), then you could end up estimating that there were less adipose clips apportioned to the fall clipping than were verified from fall adipose clips. Despite this, the marine recoveries in recent years have been similar to those inriver, and so these equations work perfunctorily.

The survival probability ϕ_1 of BY 2014 Chinook salmon from fall 2015 to spring 2016 will be estimated as:

$$\hat{\phi}_1 = \hat{N}_{SMOLT} \Big/ \hat{N}_{JUVENILE}\,. \tag{7}$$

The proportion of the fall 2015 juvenile population marked with CWTs will be estimated using:

$$\hat{q}_{FALL} = \hat{R}_{JUVENILE} / C \tag{8}$$

and the estimated proportion of the spring 2016 smolt population marked with CWTs will be estimated as:

$$\hat{q}_{SPRING} = \hat{R}_{SMOLT} / C. \tag{9}$$

To estimate the error surrounding the parameters $N_{JUVENILE}$, ϕ_1, and N_{SMOLT}, a statistical model will be fit to the BY 2014 data. The number of valid CWTs from fall and spring marking events recovered from Chinook salmon sampled in the Chilkat River in 2017-2021 will be modeled as having a multinomial distribution with parameters π_1, π_2, π_3, π_4, and C, where:

$\pi_1 = q_{FALL}\ \rho$,

$\pi_2 = q_{SPRING}\ \rho$,

$\pi_3 = (q_{FALL} + q_{SPRING})\ (1\text{-}\rho)$,

$\pi_4 = 1 - \pi_2 - \pi_3$, and

C = number of Chinook salmon captured in the Chilkat River and inspected for adipose clips in 2017–2021,

$q_{FALL} = M_{JUVENILE} / N_{JUVENILE}$

$q_{SPRING} = M_{SMOLT} / N_{SMOLT}$

ρ = the proportion of adipose-clipped fish for which the head was collected and a CWT was successfully decoded,

$M_{JUVENILE}$ = number of CWTs applied to Chinook juvenile salmon marked during fall 2015,

M_{SMOLT} = number of CWTs applied to Chinook salmon smolt marked during spring 2016,

$N_{JUVENILE}$ = abundance of Chinook juvenile salmon during the fall 2015 marking event, and

N_{SMOLT} = abundance of Chinook salmon smolt during spring 2016 marking event, equal to the product of $N_{JUVENILE}$ and

ϕ_1 = the survival probability from fall 2015 to spring 2016.

The relative proportion of fall and spring CWTs recovered in mixed stock marine fisheries also will contain information about the survival probability ϕ_1. Therefore the number of valid CWTs from the fall 2015 marking event recovered from Chinook salmon sampled elsewhere in 2017-2021 will be modeled as having a binomial distribution with parameters:

$\pi_{FALL} = q_{FALL} / (q_{FALL} + q_{SPRING})$, and

m = number of Chilkat fall and spring CWTs recovered in fisheries outside of the Chilkat River in 2017–2021.

Bayesian statistical methods will be used to estimate the parameters of the model. Bayesian methods use probability distributions to express uncertainty about model parameters. Inputs to the model include the "prior" probability distribution, which expresses knowledge about the parameters from previous experiments, outside the frame of the experiment itself. The output of a Bayesian analysis is the "posterior" distribution, which describes the new, updated knowledge about the parameters after consideration of the experimental data. Percentiles of the posterior distribution can be used to construct one-sided probability statements or two-sided intervals about the parameters. Point estimates are de-emphasized in Bayesian statistics, however the mean, median, or mode of the posterior can be used to describe the central tendency of a parameter. The standard deviation of the posterior distribution can be used as an analogue of the standard error of a point estimate in classical statistics.

Bayesian analyses require that prior probability distributions be specified for all unknowns in the model. A normal prior distribution with very large variance will be specified for $N_{JUVENILE}$, essentially equivalent to a uniform distribution. A beta (0.1, 0.1) prior will be used for ϕ_1 and ρ. All priors will be non-informative, chosen to have a negligible effect on the posterior.

Markov-Chain Monte Carlo simulation, implemented with the Bayesian software WinBUGS (Gilks et al. 1994), will be used to draw samples from the joint posterior probability distribution of all unknowns in the model. Three Markov chains will be initiated, a 4,000-sample burn-in period discarded, and 100,000+ updates generated to estimate the marginal posterior means, standard deviations, and percentiles. The diagnostic tools of WinBUGS will be used to assess mixing and convergence. Interval estimates will be obtained from percentiles of the posterior distribution. WinBUGS model code, data, initial values, and results from the 2005 brood year Chilkat River Chinook salmon analysis are in Appendix A5.

Coho Salmon

The abundance $\hat{N}_s$ of coho salmon smolt (by emigration year) will be estimated using Chapman's modification of the Petersen Method (Seber 1982:60):

$$\hat{N}_S = \frac{(n_c+1)(n_e+1)}{(m_e+1)} - 1 \tag{9}$$

$$var[\hat{N}_S] = \frac{(n_c+1)(n_e+1)(n_c - m_e)(n_e - m_e)}{(m_e+1)^2(m_e+2)} \tag{10}$$

where n_c is the number of valid CWTs (on fish that survive the tagging event) placed in smolt during the spring, n_e is the number of age 1-ocean salmon examined in the escapement that are successfully aged and found to have been smolt that emigrated from the Chilkat River during the previous spring, and m_e is the subset of n_e with successfully decoded CWTs placed at that time. The marked fractions of jacks and age 1-ocean fish are not statistically different, so in the interest of parsimony, only age 1-ocean fish are used for n_e. Because n_e represents 1-ocean coho salmon in the escapement, and this is estimated from a proportion of aged fish, there is a small amount of additional process error involved with the term n_e. However, because the proportion of 1-ocean fish in the population has averaged 0.97, the increase in error is small, and the increase in estimated variance is also small.

Fish sometimes lose their CWTs, CWTs can be lost from recovered heads, and CWTs can be unreadable. If any of these conditions occur, the estimators (equations 10 and 11) must be modified to compensate for the lost marks/CWTs (i.e., loss of m_e). This will be accomplished by adding a term $\lambda = a / t'$ (an overall rate for recovering and decoding CWTs, where a = # adipose-finclipped fish sampled and t' = # CWTs decoded) to the denominator of the Lincoln-Petersen / maximum-likelihood estimator, i.e., $\hat{N}_s^* = n_c\, n_e / m_e\, \lambda$. Variance of $\hat{N}_s^*$ will be estimated using a Monte-Carlo simulation if a suitable closed form estimator is not identified. Although the Lincoln-Petersen estimator is not unbiased, the bias should be negligible in this experiment because the numbers of fish marked, inspected, and recaptured are not small (Seber 1982).

The conditions for accurate use of the M-R method for both species/experiments are:

1. One of the following three items, a through c must hold true:
    a. all smolts/juveniles have an equal probability of being marked; *or*
    b. adults escaping to the Chilkat River have an equal chance of being inspected for marks; *or*
    c. marked fish mixed completely with unmarked fish in the population between sampling events.
2. There is no recruitment to the population between sampling events.
3. There is no trap or tagging induced behavior.
4. Fish do not lose their marks and all marks are recognizable.

Minnow traps will be operated continuously during smolt emigrations, and returning adults will be sampled almost continuously either in fish wheel catches or spawning grounds sampling. A possible late start in tagging projects, periodic sessions of high water, or varying outmigration timing in the spring could possibly cause temporal changes in probabilities of capture. However, these vagaries are troublesome only if migratory timing of smolt from sub-populations within the Chilkat River parallel that of returning adults and these vagaries are coincident in the migratory pattern for both adults and smolt. If migratory patterns of smolt are different than that of adults, marked and unmarked smolt are completely mixed in the population prior to their return as adults. We will test for temporal changes in the fraction of adults missing adipose fins: if at least one of the conditions has been met, this fraction will not change with time. Temporal changes in these fractions will be tested against a χ^2 distribution. Although fish wheels and gillnets can be size selective, their size selectivity should not be a problem because there is no relation between the size of a smolt (when marked) and the size of the returning adult (when recaptured). Because almost all surviving smolt return to their natal stream as adults to spawn, there will be no meaningful recruitment added to the population while they are at sea. Trap-induced behavior is unlikely because different sampling gears will be used to capture smolt and adults. Results from other studies (Elliott and Sterritt 1990; Vincent-Lang 1993) indicate that excising adipose fins and implanting CWTs will not increase the mortality of marked salmon.

As outlined in the Study Design section, coded-wire tagging coho salmon smolt in different size groups allows for testing of M-R assumption [1 a-c], i.e., that every fish has an equal probability of being marked during event 1, that every fish has an equal probability of being captured in event 2, or that marked fish mix completely with unmarked fish. If fish are faithful to their natal grounds and if certain tributaries have different run timings, it is possible that (marked) fish do not mix completely. Therefore in the event that χ^2 tests indicate unequal probabilities of tagging in event 1 and capture in event 2, an alternate Petersen M-R model will be used for a 2-group population. See Appendix D for details.

A coho salmon smolt population divided into 2 groups labeled (1) and (2), Petersen's M-R model can be expanded into (adapted from Weller et al. 2005):

$$N_1 + N_2 = (N_1\alpha_1 + N_2\alpha_2)\frac{N_1\alpha_1 S_1\beta_1 + N_2\alpha_2 S_2\beta_2 + N_1(1-\alpha_1)S_1\beta_1 + N_2(1-\alpha_2)S_2\beta_2}{N_1\alpha_1 S_1\beta_1 + N_2\alpha_2 S_2\beta_2} \quad (11)$$

In the above equation, N is abundance, α_i is the capture probability in event 1 for each group, S_i the survival rate for each group, and β_i the capture probability for each group.

If one or both capture probability parameters, α_i or β_i, are equal, then the above equation reduces to a more simplified version. Consider the case when $\beta_1 = \beta_2$, the abundance estimator reduces to:

$$N_1 + N_2 = (N_1\alpha_1 + N_2\alpha_2)\frac{N_1\alpha_1 S_1 + N_2\alpha_2 S_2 + N_1(1-\alpha_1)S_1 + N_2(1-\alpha_2)S_2}{N_1\alpha_1 S_1 + N_2\alpha_2 S_2} \quad (12)$$

If the relationship between α_i parameters is expressed as A= α_2 / α_1 and the relationship between S_i parameters is expressed as B = S_2 / S_1, equation (13) reduces further to:

$$N_1 + N_2 = \frac{(N_1 + AN_2)(N_1 + BN_2)}{N_1 + ABN_2} \quad (13)$$

It is important to note that equation (14) is only true if $A = 1$ (i.e. $\alpha_2 = \alpha_1$) OR if $B = 1$ ($S_2 = S_1$). If both A and B are not equal to 1, the above relationship does not hold and an unbiased estimator of abundance cannot be produced. If it is determined that there are both unequal marking probabilities (event 1) and unequal capture or survival probabilities (event 2), Petersen's model can be adjusted to produce an unbiased estimate of smolt abundance. Consider Chapman's modification of the standard Petersen model with 2 tagging groups, labeled group 1 and group 2:

$$\hat{N} = \frac{(N1_1 + N1_2 + 1)(N2 + 1)}{(M2_1 + M2_2 + 1)} \quad (14)$$

where $N1_1$ and $N1_2$ are the number marked in groups 1 and 2, $N2$ is the number inspected for marks in the second event, and $M2_1$ and $M2_2$ are the amount of marks recovered from groups 1 and 2. Consider the case where $A > 1$ and $S > 1$, that is, group 2 had both a higher marking probability and capture probability. This would create negative bias in the estimator and $N > \hat{N}$. Adjusting Chapman's modification for this tagging bias results in a new, unbiased estimator:

$$\hat{N}^* = \frac{(\hat{A}N1_1 + N1_2 + 1)(N2 + 1)}{\hat{A}M2_1 + M2_2 + 1} - 1 \quad (15)$$

Using the scalar $\hat{A}$, i.e., the ratio of marking rates of the 2 groups, essentially forces the two groups to have the same marking probability, and therefore the expected value of equation (15) equals N as a result.

Overall retention rates for coded-wire tagged fish are rarely 100%; adipose-finclipped fish sometime do not contain valid CWTs as tags are shed during freshwater or marine rearing. Also occasionally heads are lost from adipose-finclipped fish before they can become decoded. Because of this, a new parameter $\hat{\pi}$ can be used to adjust for adipose-finclipped fish with no tag information ($M2_U$), which is the observed ratio of tags recovered from group 1 divided by group 2. Basically the observed recovery rate is extrapolated for fish marked in the first event (as indicated by an adipose fin clip) that contain no tag information:

$$\hat{N}^* = \frac{\left(\hat{A}N1_1 + N1_2 + 1\right)\left(N2 + 1\right)}{\hat{A}\left(M2_1 + (\hat{\pi})M2_U\right) + M2_2 + (1 - \hat{\pi})M2_U + 1} - 1 \qquad (16)$$

In the event that all observed adipose-finclipped fish contain valid CWTs, the term $M2_U$ is zero and equation (16) is identical to equation (15).

Variance and relative bias in the modified estimator can be estimated through bootstrapping techniques outlined in Efron and Tibshirani (1993).

AGE COMPOSITION

Proportions and variance or proportions by age for coho salmon smolt and adults will be estimated:

$$\hat{\rho}_j = \frac{n_j}{n} \qquad (17)$$

$$\hat{\text{var}}[\hat{\rho}_j] = \frac{\hat{\rho}_j(1 - \hat{\rho}_j)}{n-1} \qquad (18)$$

where $\hat{\rho}_j$ is the estimated proportion in the population in group j, n is the number successfully aged, and n_j is the subset of n that belong to group j. Systematic selection of samples will promote proportional sampling and reduce bias from any inseason changes in age composition.

Collecting scale samples in fall 2017 from all returning adult coho salmon with clipped adipose fins will be done to provide the scale ager with known-age reference samples. Collecting age information from adipose-finclipped coho salmon will also allow for calculation of an unbiased smolt estimator discussed above.

ESTIMATES OF MEAN LENGTH

Standard sample summary statistics will be used to calculate estimates of mean length of Chinook salmon smolt or mean length-at-age of coho salmon smolt and adults, and their variances (Thompson 2002).

ESTIMATION OF THE CODED WIRE TAG MARKED FRACTION

The marked fractions for populations of BY 2014 Chinook salmon and for emigration year 2016 coho salmon will each be estimated separately:

$$\hat{\theta}_p = \frac{y_p}{t_p} \tag{19}$$

where

$\hat{\theta}_p$ = the proportion of juveniles from brood year p or emigration year p marked with a CWT,

y_p = number of fish in the sample missing their adipose fin that are determined to be from brood year p or emigration year p, and

t_p = number of fish in the sample determined to be from brood year p or emigration year p.

The adipose fin clip fraction will be estimated for BY 2014 Chinook salmon from event 1 and 2 of adult M-R projects in 2017-2021 (Elliott et al. 2015). The potential for the Chinook salmon θ to vary significantly by recovery area (e.g., lower river, Tahini River, Kelsall River, etc.) will be investigated using a series of χ^2 tests similar to those described above. If differences in the marked fractions are significant (α = 0.10) and large enough to lead to serious bias in estimates of smolt abundance or fisheries contributions, only samples collected in the lower river will be used to estimate θ. Deterministic modeling was done to estimate the effect on θ of tagging smolt non-proportionally on the 2 main spawning areas (Table 8). The model assumes sampling on the spawning grounds would proceed as it has in the past. As the fraction marked in the Tahini River area diverges from the fraction marked in the Kelsall River area, the estimate of θ for the river, based on spawning ground samples, varies very little. This occurs because samples are distributed from the bulk of the spawning population. Also, the model suggests that the usual χ^2 test will indicate that problems exist well before they are severe enough to lead to serious bias in estimates of smolt abundance or fisheries contributions (bias in those estimates is approximately proportional to bias in θ for the river). For example, as tagging fractions for the upriver and downriver rearing areas diverge by 100% (θ_{Tahini} = 0.089 and $\theta_{Kelsall}$ = 0.179), the resulting estimate of $\theta_{ChilkatRiver}$ = 0.148 varies by only 3.8% from its true value.

For emigration year 2016 coho salmon, the CWT marked fraction will be estimated using adult sampling data collected at the lower river fish wheel sampling site in 2017.

To estimate contributions to mixed stock marine fisheries, it is necessary to account for CWT tag loss, which prevents recognition of the stock of origin. For each Coded-wire tagged population (BY 2014 Chinook salmon, emigration year 2016 coho salmon) the marked fraction $\hat{\theta}_{marine}$ used in harvest estimates will be the product of $\hat{\theta}_p$ and the proportion of heads with decoded CWTs out of the heads sent to the Tag Lab.

HARVEST

Harvest of Chilkat River coho will be estimated by calendar year, and Chinook salmon will be estimated both by calendar year and brood year through a stratified catch sampling program of commercial and recreational fisheries. Methods in Bernard and Clark (1996) will be used to expand harvest estimates from recovered CWTs. Commercial catch data for the analysis will be summarized by ADF&G statistical week and district (for gillnet and seine fisheries), or by period and quadrant for troll fisheries. Sport harvest estimates from ADF&G Statewide Harvest Survey reports (e.g., Jennings et al. 2007) will be apportioned using information from sampled marine sport fisheries to obtain estimates of total harvest by bi-week and fishery. Sport fish CWT recovery data will be obtained from Tag Lab reports and summarized by bi-week and fishery (e.g., bi-week 16 during the Sitka Marine Creel Survey) to estimate contribution. In most cases, CWTs of interest may be recovered in only a few of the sport fish sampling strata that defined the fishery bi-week. Assuming that the harvests of fish with CWTs of interest are independent of sampling strata within fishery bi-weeks, harvests and sampling information will be totaled over the fishery bi-week to estimate contributions."

The estimates will be based on information from SF and CF sampling of:

1. number of salmon harvested by species;
2. fraction of the harvest inspected for missing adipose fins;
3. number of salmon in the sample with missing adipose fins;
4. number of fish heads that reached the Tag Lab;
5. number of these heads that contained CWTs;
6. number of these CWTs that were decodable; and
7. number of decodable tags of the appropriate code(s).

As noted above, estimating tagging fractions θ for Chinook salmon is complicated by adults returning over 5 years. Data from all sample years will be pooled to estimate $\hat{\theta}_{marine}$ for the harvest study.

SCHEDULE AND DELIVERABLES

Adult coho salmon will be sampled in the fish wheels beginning about August 1 and extending through October 15, 2017. Field activities for Chinook juvenile salmon will begin inriver approximately September 16, 2015 and extend through October 31, 2015. Data editing and analysis will be initiated before the end of each season. A memorandum summarizing fall field activities, successes, and suggestions for improvement will be submitted to the project biologist by November 30. Field activities for smolt will begin inriver approximately April 3, 2016, and extend until May 15, 2016, or as river conditions permit. Data editing and analysis will be initiated before the end of each season. A memorandum summarizing smolt field activities, successes, and suggestions for improvement will be submitted to the regional Chinook salmon research coordinator by June 15, 2016.

Juvenile Chinook trapping and tagging data collected in this study will be reported in a Division of Sport Fish Fishery Data Series report and submitted by December 31, 2021. Coho salmon smolt data collected in 2016 will be reported in a Division of Sport Fish Fisheries Data Series report and submitted by December 1, 2017. This report will cover all 2016 smolt data and subsequent recoveries, harvest contributions, etc. of adult coho salmon in 2017. Chinook juvenile and smolt data including adult harvests will be reported by December 2021.

RESPONSIBILITIES

Brian W. Elliott, FB III, Lead Biologist. The Lead Biologist sets up all major aspects of the project, including planning, budget, sample design, permits, equipment, personnel, and training. This position will oversee all field operations for juvenile tagging and adult abundance estimation. This position will also assist in the field during the spring CWT project, including tagging, data collection, and general field duties. This position also supervises the overall project; edits, analyzes, and reports Chinook salmon data; assists with fieldwork; arranges logistics with the field crew, area management biologist, and expeditor. Coauthors operational plan and assures that it is followed or modified appropriately.

Sarah Power, Biometrician II. The Biometrician provides input to and approves sampling design. Coauthors operational plan and provides biometric details. Reviews and assists with data analysis and final report.

Jeff Nichols, Regional Research Supervisor. The Regional Research Supervisor provides input to and approves sampling design. Reviews operational plan and provides operational details. Reviews and assists with data analysis and final report.

Richard Chapell, FB III, Area Management Biologist (AMB). The AMB performs index counts for the adult coho escapement estimation project. This position will periodically participate in field operations during the spring CWT project. The AMB will also derive harvest estimates from the Haines marine boat fishery. This position will direct field activities from the Haines ADF&G Office in the absence of Lead Biologist.

Dana Van Burgh, Reed Barber, and Aaron Thomas, FWT III. These positions act as crew leaders for CWT operations and make sure the operational plan is followed. Crew leaders will be in charge of running minnow trap lines, and adjusting traps to maximize catches, and are responsible for recording all daily records on daily forms. These positions are responsible for assisting in all aspects of field operations, including safe operation of riverboats and all other equipment, tagging, data collection, and general field camp duties including keeping camp and field equipment neat and orderly. They will be the lead smolt taggers and are responsible, along with Elliott, for making sure that species identification is done correctly and that tag retention is at or near 100%. Will take the lead roles in any construction activities and will be in charge of equipment maintenance (outboards, CWT machines, detectors, power tools, generators, etc). Will do inventory at end of year in cooperation with Elliott.

Mark Brouwer, Lyndsey Hura, and Liam Cassidy, FWT II. These positions are responsible for assisting in all aspects of field operations, including safe operation of riverboats and all other equipment, tagging, data collection and general field camp duties including keeping camp and field equipment neat and orderly. These positions are typically clippers in tagging shed, but may be trained as taggers, and will assist crew leaders with data collection and entry as needed.

Dave Folletti, FWT III (Commercial Fish Division). As leader of the Chilkat River fish wheels project, this position will capture and sample adult Chinook and coho salmon for age, sex, length, and adipose fin clip status. This position will also collect heads from ad-clipped fish that meet the CWT recovery criteria. This position will also submit sample data in a timely manner to the Lead Biologist.

TABLES AND FIGURES

(Tables 1 – 8; Figures 1 – 6)

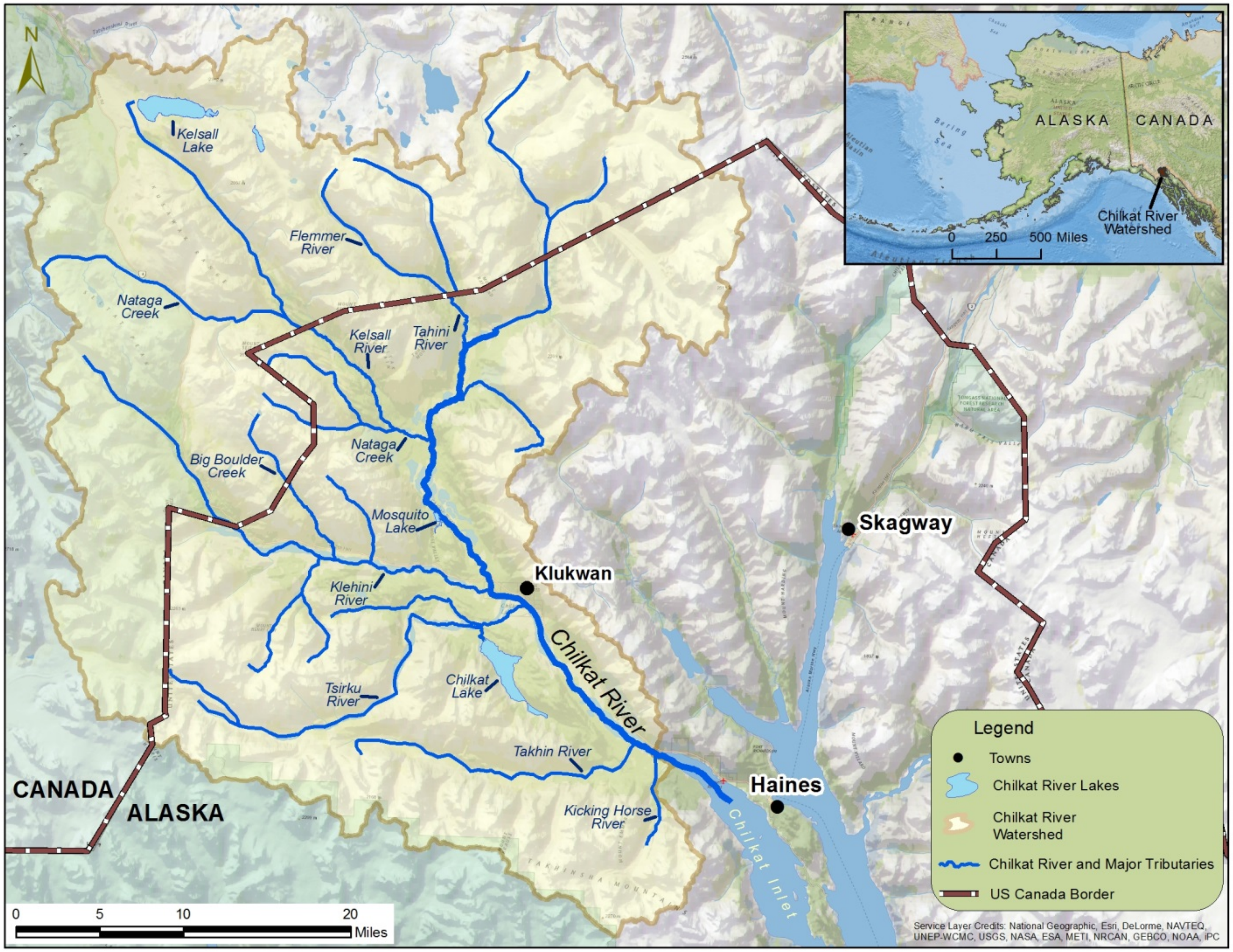

Figure 1.–The Chilkat River drainage in Southeast Alaska.

Table 1.–Chilkat Chinook salmon age ≥1.2 harvest summary by fishery, 2004–2014, Southeast Alaska.

Return Year	Winter Troll	Spring Troll	Summer Troll	Drift Gillnet	SEAK Sport	Purse Seine	Haines Sport	Haines Subsistence
2004	0	257	95	333	18	0	269	122
2005	32	107	236	242	87	14	165	77
2006	161	138	15	31	181	94	86	96
2007	177	229	154	201	158	0	177	69
2008	96	189	218	226	18	0	5	52
2009	153	241	84	79	13	0	80	75
2010	93	351	434	358	127	44	120	85
2011	115	822	0	244	84	109	173	114
2012	155	141	319	235	49	43	153	96
2013	0	40	0	200	74	13	74	69
2014	0	117	0	520	26	39	197	79
2004-2014 avg.	89	239	141	243	76	32	136	85
Proportion of average harvest	0.08	0.23	0.13	0.23	0.07	0.03	0.13	0.10

Table 2.–Estimated inriver abundance, inriver harvest, and escapement of large Chinook salmon in the Chilkat River, 1991–2014.

Year	Inriver abundance	Inriver harvest	Escapement	SE (esc)	CV
1991[a]	5,897	15	5,882	1,005	0.17
1992[b]	5,284	7	5,277	949	0.18
1993[c]	4,472	9	4,463	851	0.19
1994[d]	6,795	3	6,792	1,057	0.16
1995[e]	3,790	22	3,768	805	0.21
1996[f]	4,920	18	4,902	751	0.15
1997[g]	8,100	11	8,089	1,193	0.15
1998[h]	3,675	19	3,656	565	0.15
1999[i]	2,271	13	2,258	408	0.18
2000[j]	2,035	6	2,029	334	0.16
2001[k]	4,517	3	4,514	722	0.16
2002[l]	4,050	16	4,034	433	0.11
2003[m]	5,657	26	5,631	690	0.12
2004[n]	3,422	16	3,406	456	0.13
2005[o]	3,366	5	3,361	554	0.16
2006[p]	3,039	36	3,003	380	0.13
2007[q]	1,442	7	1,435	230	0.16
2008[r]	2,905	24	2,881	452	0.16
2009[s]	4,429	23	4,406	589	0.13
2010[t]	1,815	18	1,797	308	0.17
2011[u]	2,688	14	2,674	357	0.13
2012[v]	1,744	21	1,723	267	0.15
2013[w]	1,730	11	1,719	338	0.20
2014[x]	1,534	5	1,529	307	0.20
1994-2014 Avg.	3,520	15	3,505	533	0.16

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Table 2.—page 2 of 2.

a	Taken from Johnson et al. (1992).	m	Taken from Ericksen (2004).
b	Taken from Johnson et al. (1993).	n	Taken from Ericksen (2005).
c	Taken from Johnson (1994).	o	Taken from Ericksen et al. (2006)
d	Taken from Ericksen (1995).	p	Taken from Chapell (2009).
e	Taken from Ericksen (1996).	q	Taken from Chapell (2010).
f	Taken from Ericksen (1997).	r	Taken from Chapell (2012).
g	Taken from Ericksen (1998).	s	Taken from Chapell (2013a).
h	Taken from Ericksen (1999).	t	Taken from Chapell *(*2013b).
i	Taken from Ericksen (2000).	u	Taken from Chapell *(in prep a*).
j	Taken from Ericksen (2001).	v	Taken from Chapell *(in prep b*).
k	Taken from Ericksen (2002).	w	Taken from Elliott (*in prep a*)
l	Taken from Ericksen (2003).	x	Taken from Elliott (*in prep b*)

Table 3.–Number of coded wire tagged Chinook salmon released into the Chilkat River by brood year (BY) and year of release, through spring 2015.

Brood year	Capture/release site	Release year	Stage	Total tagged	Shed tags	Valid tags
BY 1984 total	Tahini River	1985	Fed fry	42,961	601	42,360
BY 1985 total	Tahini River	1986	Fed fry	46,478	1,457	44,120
BY 1987 total	Kelsall River	1988	Juvenile	4,553	0	4,553
1988	Chilkat River	1989	Juvenile	9,897	119	9,778
1988	Chilkat River	1990	Smolt	2,220	29	2,191
1988	Kelsall River	1989	Juvenile	20,199	120	20,079
1988	Tahini River	1989	Juvenile	5,293	0	5,293
BY 1988 total				37,609	268	37,341
1989	Chilkat River	1990	Juvenile	2,230	0	2,230
1989	Kelsall River	1990	Juvenile	10,242	82	10,160
1989	Tahini River	1990	Fed fry	30,146	180	29,966
1989	Tahini River	1990	Juvenile	1,403	0	1,403
BY 1989 total				44,021	262	43,759
BY 1990 total	Tahini River	1991	Fed fry	36,316	796	35,520
1991	Big Boulder Creek	1992	Fed fry	44,820	1,470	43,018
1991	Tahini River	1992	Fed fry	62,579	2,024	60,555
BY 1991 total				107,399	3,494	103,573
BY 1992 total	Big Boulder Creek	1993	Fed fry	23,389	1,614	21,775
1993	Big Boulder Creek	1994	Emergent fry	24,324	243	24,081
1993	Big Boulder Creek	1994	Fed fry	28,062	1,516	26,546
BY 1993 total				52,386	1,759	50,627
BY 1994 total	Big Boulder Creek	1995	Emergent fry	45,060	2,569	42,491
BY 1995 total	Big Boulder Creek	1996	Emergent fry	62,014	3,082	58,556
BY 1997 total	Chilkat River	1999	Smolt	771	0	771
1998	Lower Chilkat	2000	Smolt	446	0	446
1998	Upper Chilkat	2000	Smolt	1,550	0	1,550
BY 1998 total				1,996	0	1,996
1999	Chilkat River	2000	Juvenile	6,974	0	6,974
1999	Kelsall River	2000	Juvenile	17,647	0	17,647
1999	Klehini River	2000	Juvenile	173	0	173
1999	Tahini	2000	Juvenile	5,310	0	5,310
1999	Lower Chilkat	2001	Smolt	4,506	0	4,506
BY 1999 total				34,610	0	34,610
2000	Tahini River	2001	Juvenile	2,740	0	2,740
2000	Kelsall River	2001	Juvenile	10,913	0	10,913
2000	Lower Chilkat	2001	Juvenile	9,470	0	9,470
2000	Lower Chilkat	2002	Smolt	4,714	5	4,709
BY 2000 total				27,837	5	27,832

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Table 3.–Page 2 of 3.

Brood year	Capture/release site	Release year	Stage	Total tagged	Shed tags	Valid tags
2001	Tahini River	2002	Juvenile	6,519	0	6,519
2001	Kelsall River	2002	Juvenile	18,251	0	18,251
2001	Lower Chilkat	2002	Juvenile	6,620	0	6,620
2001	Lower Chilkat	2003	Smolt	2,797	0	2,797
BY 2001 total				34,187	0	34,187
2002	Tahini River	2003	Juvenile	4,939	0	4,939
2002	Kelsall River	2003	Juvenile	17,039	0	17,039
2002	Lower Chilkat	2003	Juvenile	14,662	0	14,662
2002	Lower Chilkat	2004	Smolt	5,707	0	5,707
BY 2002 total				42,347	0	42,347
2003	Tahini River	2004	Juvenile	5,671	0	5,671
2003	Kelsall River	2004	Juvenile	19,395	0	19,395
2003	Lower Chilkat	2004	Juvenile	12,179	0	12,179
2003	Lower Chilkat	2005	Smolt	5,825	16	5,809
BY 2003 total				43,160	16	43,054
2004	Tahini River	2005	Juvenile	6,473	0	6,473
2004	Kelsall River	2005	Juvenile	17,867	0	17,867
2004	Lower Chilkat	2005	Juvenile	10,356	0	10,356
2004	Lower Chilkat	2006	Smolt	5,080	5	5,075
BY 2004 total				39,776	5	39,771
2005	Tahini River	2006	Juvenile	2,832	0	2,832
2005	Kelsall River	2006	Juvenile	15,205	0	15,205
2005	Chilkat River	2006	Juvenile	281	0	281
2005	Chilkat River	2007	Smolt	2,239	1	2,238
BY 2005 total				20,557	1	20,556
2006	Tahini River	2007	Juvenile	5,273	0	5,273
2006	Kelsall River	2007	Juvenile	12,196	0	12,196
2006	Chilkat River	2007	Juvenile	11,180	0	11,180
2006	Chilkat River	2008	Smolt	2,499	0	2,499
BY 2006 total				31,148	0	31,148
2007	Tahini River	2008	Juvenile	3,947	0	3,947
2007	Kelsall River	2008	Juvenile	9,866	0	9,866
2007	Chilkat River	2008	Juvenile	6,361	0	6,361
2007	Chilkat River	2009	Smolt	3,911	0	3,911
BY 2007 total				24,085	0	24,085
2008	Tahini River	2009	Juvenile	3,041	0	3,041
2008	Kelsall River	2009	Juvenile	4,784	0	4,784
2008	Chilkat River	2009	Juvenile	8,162	0	8,162
2008	Chilkat River	2010	Smolt	995	0	995
BY 2008 total				16,982	0	16,982

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Table 3.–Page 3 of 3.

Brood year	Capture/release site	Release year	Stage	Total tagged	Shed tags	Valid tags
2009	Tahini River	2010	Juvenile	7,254	0	7,254
2009	Kelsall River	2010	Juvenile	15,883	0	15,883
2009	Chilkat River	2010	Juvenile	15,703	25	15,678
2009	Chilkat River	2011	Smolt	5,514	0	5,514
BY 2009 total				44,354	25	44,329
2010	Tahini River	2011	Juvenile	1,840	0	1,840
2010	Kelsall River	2011	Juvenile	8,534	0	8,534
2010	Chilkat River	2011	Juvenile	15,986	0	15,986
2010	Chilkat River	2012	Smolt	3,175	0	3,175
BY 2010 total				29,535	0	29,535
2011	Tahini River	2012	Juvenile	4,973	0	4,973
2011	Kelsall River	2012	Juvenile	10,173	0	10,173
2011	Chilkat River	2012	Juvenile	11,726	0	11,726
2011	Chilkat River	2013	Smolt	5,917	6	5,911
BY 2011 total				32,789	6	32,783
2012	Tahini River	2013	Juvenile	5,408	0	5,408
2012	Kelsall River	2013	Juvenile	6,663	0	6,663
2012	Chilkat River	2013	Juvenile	8,211	0	8,211
2012	Chilkat River	2014	Smolt	1,875	0	1,875
BY 2012 total				22,157	0	22,157
2013	Tahini River	2014	Juvenile	3,551	0	3,551
2013	Kelsall River	2014	Juvenile	3,428	0	3,428
2013	Chilkat River	2014	Juvenile	11,282	0	11,282
2013	Chilkat River	2015	Smolt	2,829	0	2,829
BY 2013 total				21,090	0	21,090

Table 4.–Summary of Chilkat Chinook salmon ≥age-1.2 production and harvest estimates from coded wire tag studies, brood years 1988–1989, 1991, and 1999–2008.

PRODUCTION/HARVEST ESTIMATES (≥Age-1.2)												
					Marine harvest by fishery type							
Brood year (BY)	Fall juveniles	Overwinter survival	Smolt	Marked fraction, inriver	Commercial	Sport	Subsistence	Total harvest	Inriver return	Total return	Marine exploitation	Smolt to ≥age-1.2 survival
1988[a]	ND	ND	ND	0.037	910	719	9	1,638	7,111	8,749	0.187	ND
1989[a]	ND	ND	ND	0.110	283	373	27	683	6,233	6,916	0.099	ND
1991[b]	ND	ND	ND	0.048	681	374	58	1,006	11,900	12,906	0.078	ND
1998[c]	ND	ND	123,680	0.015	191	849	ND	1,040	3,596	4,636	0.224	0.037
1999[d]	386,400	0.361	139,500	0.112	508	680	84	1,272	4,764	6,036	0.211	0.043
2000[e]	510,700	0.206	105,300	0.102	404	308	63	775	4,173	4,948	0.157	0.047
2001[f]	596,410	0.249	148,800	0.071	508	302	81	891	4,562	5,453	0.163	0.037
2002[g]	509,700	0.381	194,000	0.106	689	152	24	866	1,572	2,438	0.355	0.013
2003[h]	669,200	0.422	282,700	0.078	987	115	41	1,143	5,488	6,631	0.172	0.023
2004[i]	530,300	0.223	118,500	0.111	507	110	19	636	3,283	3,919	0.162	0.033
2005[j]	271,700	0.531	144,200	0.086	1,094	164	44	1,303	3,126	4,429	0.294	0.031
2006[k]	566,900	0.491	278,155	0.058	1,164	289	64	1,517	2,555	4,072	0.373	0.015
2007[l]	363,206	0.416	151,218	0.080	936	267	97	1,299	3,765	5,064	0.257	0.033
2008[m]	344,600	0.411	141,800	0.061	412	129	28	569	1,274	1,844	0.309	0.013
1999–2008 avg.	474,912	0.359	170,417	0.087	721	252	55	1,027	3,456	4,483	0.245	0.029

-continued-

Table 4.–Page 2 of 2.

STANDARD ERRORS of PRODUCTION/HARVEST ESTIMATES (≥Age-1.2)												
					Marine harvest by fishery type							
Brood year (BY)	Fall juveniles	Overwinter survival	Smolt	Marked fraction, inriver	Commercial	Sport	Subsistence	Total harvest	Inriver return	Total return	Marine exploitation	Smolt to ≥age-1.2 survival
1988[a]	ND	ND	ND	0.009	235	327	1	403	789	885	NE	ND
1989[a]	ND	ND	ND	0.019	74	132	2	152	781	796	NE	ND
1991[b]	ND	ND	ND	0.008	176	124	2	210	1,167	1,186	NE	ND
1998[c]	ND	ND	30,554	0.004	190	706	ND	731	488	879	12.5	1.2
1999[d]	38,020	0.065	21,920	0.009	96	166	5	192	562	594	0.032	0.008
2000[e]	74,290	0.048	17,170	0.010	124	104	3	162	681	700	0.035	0.010
2001[f]	87,540	0.101	49,770	0.008	198	111	6	227	727	762	0.041	0.013
2002[g]	81,390	0.106	47,020	0.015	170	59	2	180	231	293	0.058	0.003
2003[h]	75,720	0.083	49,420	0.008	224	27	4	225	652	690	0.033	0.005
2004[i]	70,280	0.045	19,180	0.012	121	32	2	125	460	476	0.033	0.007
2005[j]	34,470	0.146	36,260	0.010	217	40	4	220	353	417	0.042	0.008
2006[k]	166,189	0.188	77,401	0.009	225	88	6	242	265	358	0.044	0.004
2007[l]	363,206	0.416	151,218	0.009	241	75	9	252	446	512	0.043	0.007
2008[m]	344,600	0.411	141,800	0.013	139	43	2	145	234	276	0.067	0.007
1999–2008 avg.	133,571	0.161	61,116	0.010	175	75	4	197	461	508	0.043	0.007

Note: ND = no data.

Note: NE = not estimated.

[a] Data from Ericksen (1996).

[b] Data from Ericksen (1999).

[c] Data from Ericksen et al. (2006).

[d] Data from Chapell (2009).

[e] Data from Chapell (2010).

[f] Data from Chapell (2012).

[g] Data from Chapell (2013a).

[h] Data from Chapell (2013b).

[i] Data from Chapell (*in prep a*).

[j] Data from Chapell (*in prep b*).

[k] Data from Elliott (*in prep a*).

[l] Data from Elliott (*in prep b*).

[m] Data from Elliott (*in prep c*).

Table 5.–Production and harvest estimates for 1-ocean-age Chilkat River coho salmon, 2000–2014.

Return year, t	Number CWT smolt (t-1)	Smolt theta (θ_s)	Smolt estimate	SE	Marine theta (θ_m)	Marine harvest	SE	Inriver harvest	SE	Age-x.1 esc	SE	Total return	SE	Marine expl	SE	Marine survival	SE
2000[a]	25,915	0.019	1,237,056	219,715	0.019	39,546	3,745	853	221	84,843	16,330	125,242	16,755	0.32	0.05	0.10	0.02
2001[b]	25,016	0.021	1,185,804	164,121	0.020	45,658	7,194	2,176	451	107,697	20,720	155,531	21,938	0.29	0.05	0.13	0.03
2002[c]	36,114	0.012	2,970,458	377,695	0.012	110,105	10,355	3,888	742	204,787	31,071	318,780	32,759	0.35	0.04	0.11	0.02
2003[d]	25,296	0.015	1,696,212	190,330	0.015	83,302	6,956	2,932	497	133,109	14,926	219,291	16,474	0.38	0.03	0.13	0.02
2004[e]	24,563	0.012	1,938,322	401,419	0.010	128,466	19,882	3,169	661	67,053	12,901	198,688	23,710	0.65	0.05	0.10	0.03
2005[f]	17,276	0.021	776,934	147,738	0.020	29,518	3,483	1,453	293	34,575	4,561	65,546	5,746	0.45	0.04	0.08	0.02
2006[g]	26,342	0.014	1,807,837	217,352	0.013	70,813	7,632	2,082	293	79,050	15,210	151,945	17,020	0.47	0.05	0.08	0.01
2007[h]	22,149	0.025	875,478	134,864	0.023	12,142	1,585	635	149	24,770	4,769	37,547	5,027	0.32	0.05	0.04	0.01
2008[i]	24,104	0.027	893,032	95,380	0.025	52,989	3,518	991	261	56,369	10,846	110,349	11,405	0.48	0.05	0.12	0.02
2009[j]	23,059	0.032	716,689	88,013	0.031	30,558	2,585	2,424	421	47,911	9,219	80,893	9,584	0.38	0.05	0.11	0.02
2010[k]	24,937	0.028	872,829	151,981	0.026	68,385	5,165	706	138	85,066	16,375	154,157	17,171	0.44	0.05	0.18	0.04
2011[l]	26,877	0.026	1,026,314	162,061	0.022	34,161	2,585	1,437	289	61,099	15,747	96,698	15,961	0.35	0.06	0.09	0.02
2012[m]	31,092	0.024	1,229,468	242,671	0.021	27,913	2,375	398	165	36,961	7,441	65,272	7,813	0.43	0.05	0.05	0.01
2013[n]	18,307	0.023	788,387	135,519	0.023	68,226	7,673	1,014	281	51,319	9,874	120,559	12,508	0.57	0.05	0.15	0.03
2014[o]	10,834	0.012	875,312	114,920	0.011	26,491	3,315	2,581	520	130,200	25,050	159,272	25,274	0.17	0.03	0.18	0.04
Avg. 2000-2014	24,125	0.021	1,259,342	189,585	0.019	55,218	5,870	1,783	359	80,321	14,336	137,318	15,943	0.40	0.05	0.11	0.02

[a] From Ericksen (2001b).
[b] From Ericksen (2002b).
[c] From Ericksen (2003).
[d] From Ericksen and Chapell (2005).
[e] From Ericksen and Chapell (2006).
[f] From Ericksen (2006).
[g] From Elliott (2009).
[h] From Elliott (2010).
[i] From Elliott (2012a).
[j] From Elliott (2012b).
[k] From Elliott (2013).
[l] From Elliott (*in prep a*).
[m] From Elliott (*in prep b*).
[n] From Elliott (*in prep c*).
[o] From Elliott (*in prep d*).

Table 6.–Number of coded wire tagged coho salmon released into the Chilkat River by year of release, through 2015.

Release year	Capture site	Stage	Total marked	Shed tags	Valid tags
1976 total	Chilkat River[a]	Juvenile	9,074	0	9,074
1977	Chilkat Lake	Juvenile	6,344	0	6,344
1977	Chilkat ponds[b]	Juvenile	2,729	0	2,729
1977 total			9,073	0	9,073
1981 total	Chilkat Lake	Juvenile	2,603	0	2,603
1982 total	Chilkat ponds	Juvenile	8,608	93	8,515
1984 total	Chilkat ponds	Juvenile	14,644	102	14,542
1999	Chilkat River	Smolt	12,037	10	12,027
1999	Chilkat Lake	Smolt	4,078	0	4,078
1999	Chilkat tributaries	Smolt	9,800	29	9,771
1999 total			25,915	39	25,876
2000	Chilkat tributaries	Smolt	9,980	20	9,960
2000	Lower Chilkat River	Smolt	11,953	4	11,949
2000	Upper Chilkat River	Smolt	3,083	0	3,083
2000 Total			25,016	24	24,992
2001 Total	Lower Chilkat River	Smolt	36,114	117	35,997
2002 Total	Lower Chilkat River	Smolt	25,296	7	25,289
2003 Total	Lower Chilkat River	Smolt	24,563	4	24,559
2004 Total	Lower Chilkat River	Smolt	17,279	0	17,279
2005 Total	Lower Chilkat River	Smolt	26,342	16	26,326
2006 Total	Lower Chilkat River	Smolt	22,168	24	22,149
2007 Total	Lower Chilkat River	Smolt	24,104	0	24,104
2008 Total	Lower Chilkat River	Smolt	23,059	0	23,059
2009 Total	Lower Chilkat River	Smolt	24,937	0	24,937
2010 Total	Lower Chilkat River	Smolt	26,932	55	26,877
2011 Total	Lower Chilkat River	Smolt	31,101	9	31,092
2012 Total	Lower Chilkat River	Smolt	18,353	46	18,307
2013 Total	Lower Chilkat River	Smolt	10,878	44	10,834
2014 Total	Lower Chilkat River	Smolt	8,661	0	8,661
2015 Total	Lower Chilkat River	Smolt	9,318	0	9,318
			2001-2014 AVG		21,919

[a] This includes several locations throughout the drainage including the airport tributaries in 1976.
[b] Chilkat ponds refers to several ponds throughout the drainage where fish access was improved.

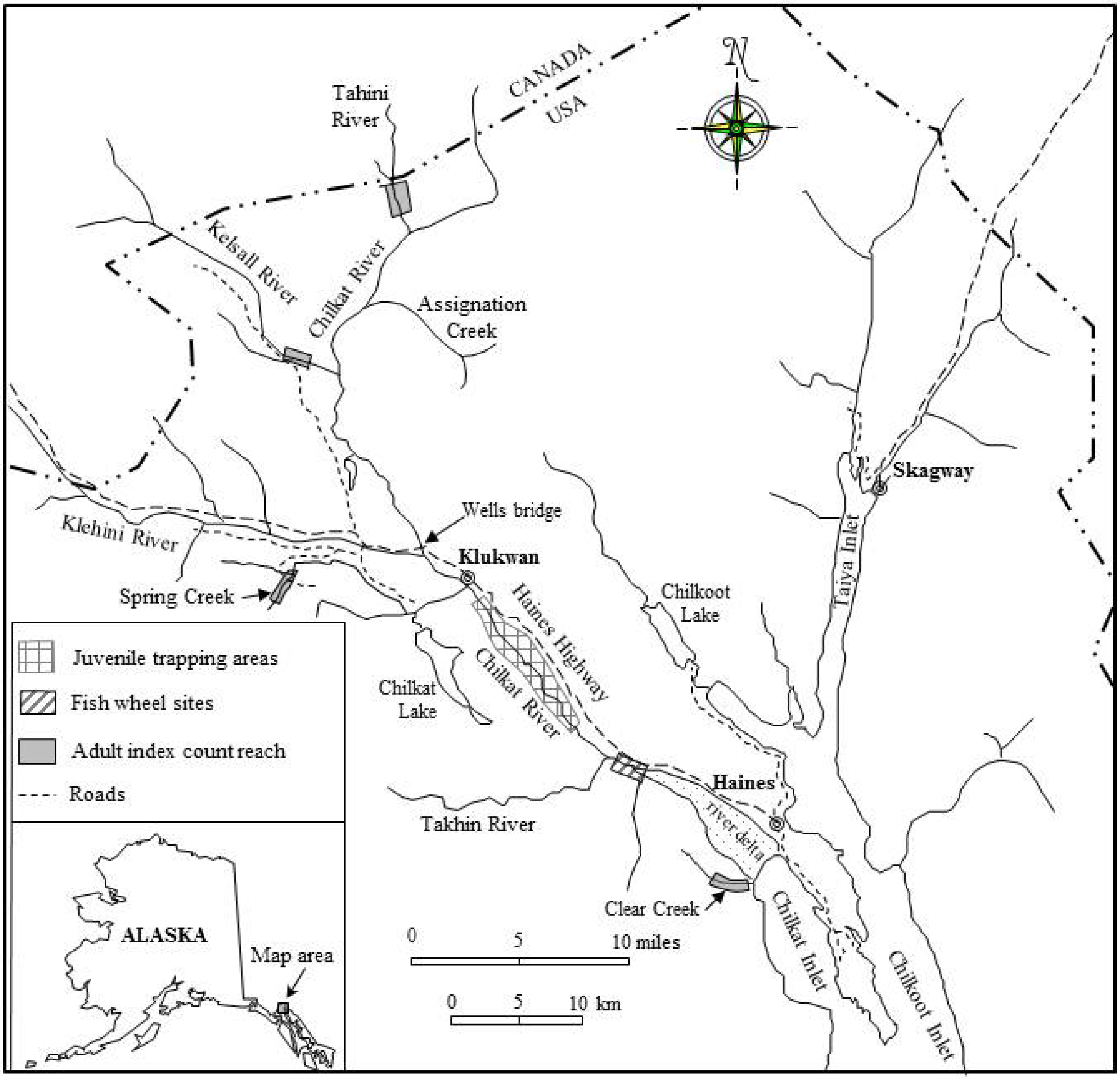

Figure 2.–Coho salmon sampling sites in the Chilkat River drainage in Southeast Alaska.

Table 7.– Peak survey counts of Chilkat River coho salmon in the Chilkat River drainage, 1987–2014, including mark-recapture estimates from 1990, 1998, 2002, 2003, and 2005.

	Peak Surveys						
	Spring Ck.	Kelsall R.	Tahini R.	Clear Ck.	Combined (C_t)	**Estimated Escapement ($\hat{N}$)**	**SE (N^)**
1987[a]	99	197	792	25	1,113	37,432	7,202
1988[a]	87	160	590	40	877	29,495	5,675
1989[a]	57	190	1,064	141	1,452	48,833	9,395
1990[b]	88	379	2,766	150	3,383	79,807	9,980
1991[a]	176	417	1,785	135	2,513	84,517	16,260
1992[a]	183	281	1,143	700	2,307	77,588	14,927
1993[a]	101	129	1,041	460	1,731	58,217	11,200
1994[a]	451	440	4,482	408	5,781	194,425	37,405
1995[a]	268	197	1,033	189	1,687	56,737	10,916
1996[a]	204	179	412	315	1,110	37,331	7,182
1997[a]	227	133	684	250	1,294	43,519	8,373
1998[b]	271	265	649	275	1,460	50,758	10,698
1999[a]	335	207	962	195	1,699	57,140	10,993
2000[a]	305	571	1,324	435	2,635	88,620	17,050
2001[a]	450	225	1,272	1,285	3,232	108,698	20,912
2002[b]	1,328	440	2,582	1,310	5,660	205,429	31,165
2003[b]	500	356	1,419	1,675	3,950	134,340	15,070
2004[a]	564	170	827	445	2,006	67,465	12,980
2005[b]	221	42	219	495	977	38,589	4,625
2006[a]	503	220	761	915	2,399	80,683	15,523
2007[a]	55	51	415	237	758	25,493	4,905
2008[a]	337	64	779	526	1,706	57,376	11,039
2009[a]	183	159	429	682	1,453	48,867	9,402
2010[a]	439	58	1,122	1,031	2,650	89,124	17,147
2011[a]	221	66	882	810	1,979	66,557	12,805
2012[a]	164	50	589	347	1,150	38,677	7,441
2013[a]	151	13	522	860	1,546	51,995	10,003
2014[a]	720	45	1,658	1,503	3,926	132,038	25,403
Mean	310	204	1,150	566	2,230	74,634	13,417
					Expansion factor (pi)	33.6	
					SE(pi)	6.5	

[a] Estimation Method is expanded survey

[b] Estimation Method is mark-recapture

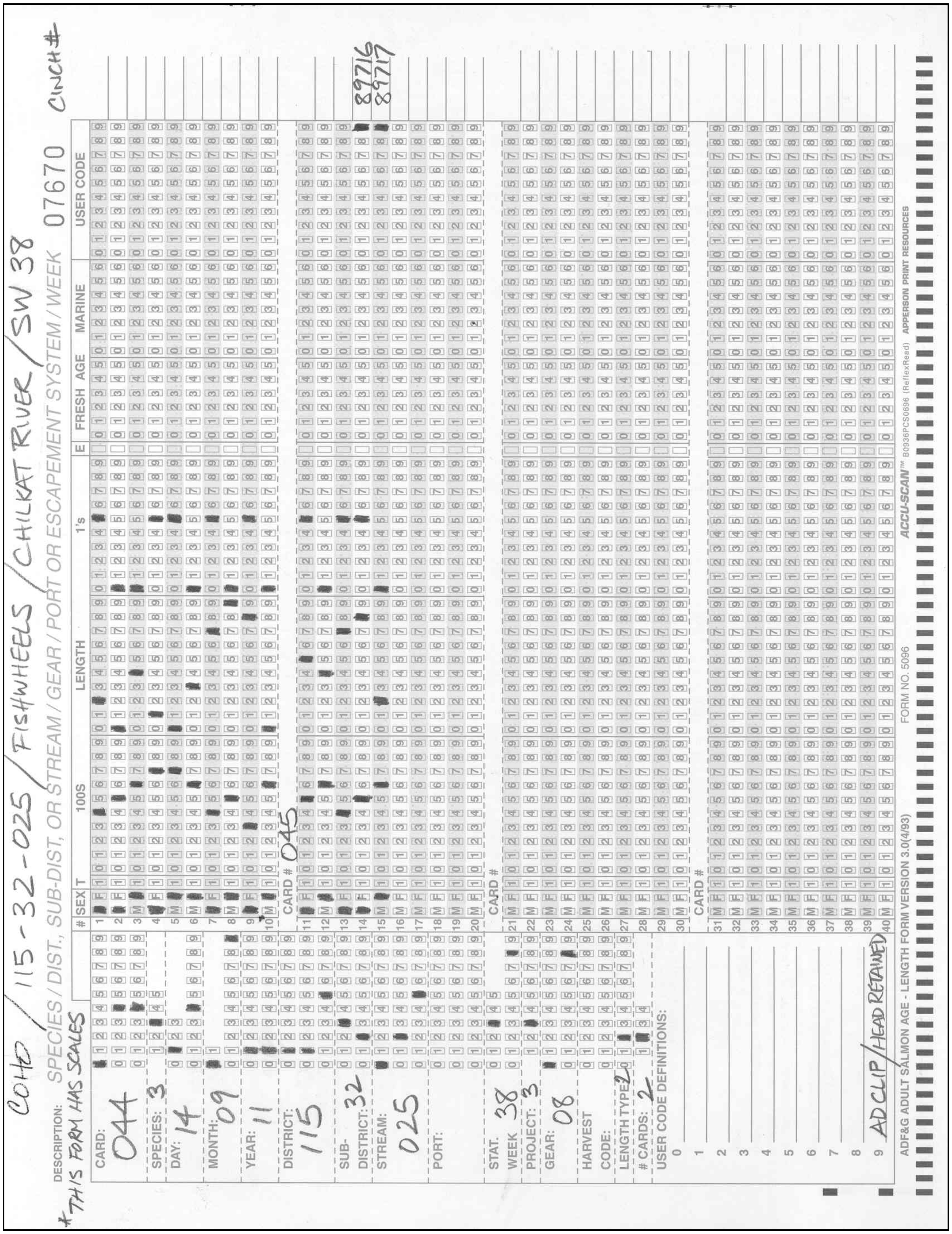

Figure 3.–Example of ADF&G adult salmon age-length form to record sex, length, and scale sample data from the first 13 of 40 coho salmon caught in fish wheels, and from any coho salmon with a clipped adipose fin.

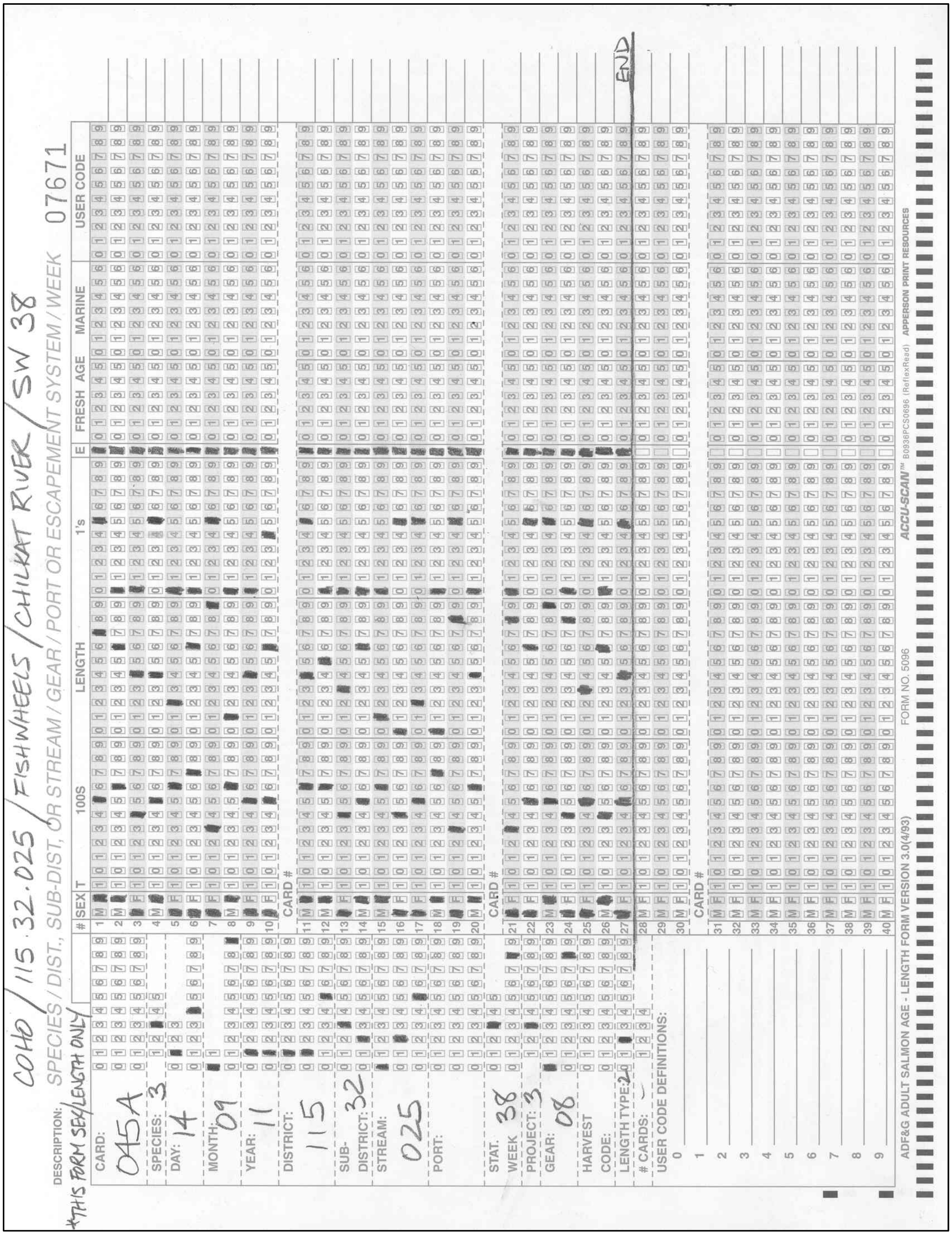

Figure 4.–Example of ADF&G adult salmon age-length form to record sex, length, and scale sample data from the last 27 of 40 coho salmon caught in fish wheels.

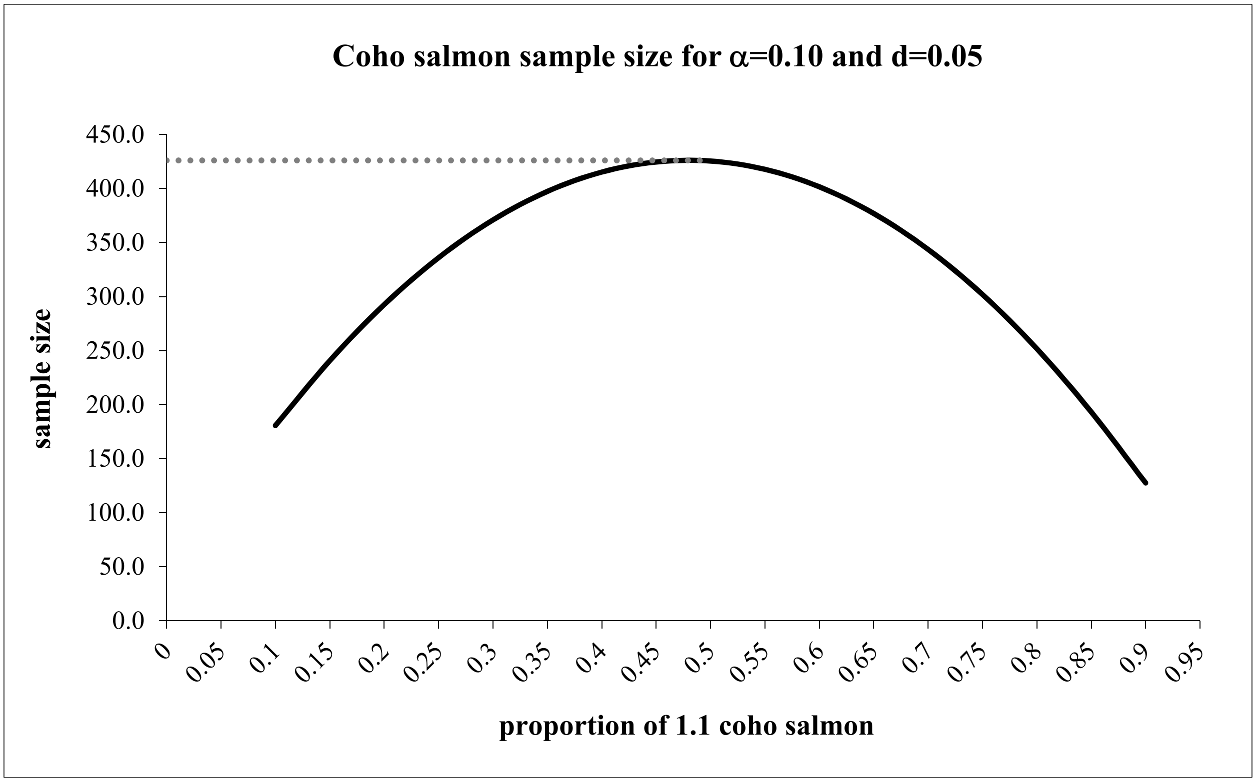

Figure 5.–Maximum number of Chilkat coho salmon smolt scale samples required, from Thompson (2002), based on an alpha value of 0.10 and precision value of 0.05.

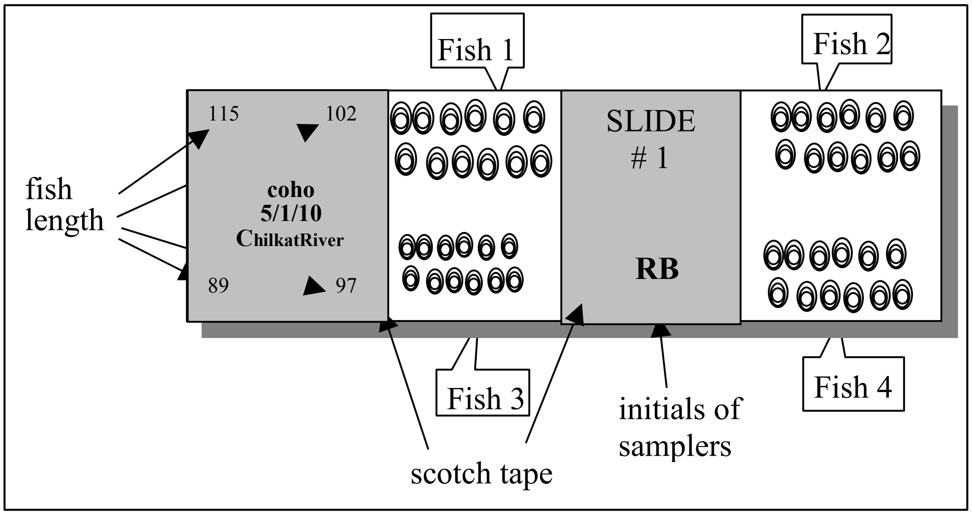

Figure 6.–Preferred microscope slide layout for coho salmon smolt scale samples.

Table 8.–Model results used to determine the effect of non-proportional tagging of smolt on the estimate of the overall marked fraction (θ) in the Chilkat River and tributary systems.

θ(area) and estimated θ (whole river) vs tagging bias				% Difference in θs			
Model	θ =Tahini	θ =Kelsall	θ estimate =combined	Absolute difference in areas	% Difference relative to Tahini	% Error in combined	χ^2 Detects difference (p = 0.1)
Unbiased	0.154	0.154	0.154	0.000	0	0.0	NA
20%	0.134	0.161	0.152	0.027	20	-1.1	No
40%	0.119	0.167	0.151	0.048	40	-2.0	No
60%	0.107	0.172	0.150	0.064	60	-2.7	No
80%	0.098	0.176	0.149	0.078	80	-3.3	Yes
100%	0.089	0.179	0.148	0.089	100	-3.8	Yes
120%	0.082	0.181	0.147	0.099	120	-4.2	Yes
250%	0.055	0.192	0.145	0.137	250	-5.8	Yes
1000%	0.019	0.206	0.142	0.187	1000	-7.9	Yes

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APPENDIX A

Appendix A1.–Anticipated number of fish released with coded wire tags (CWT) and adipose fin clips in 2016, using the average traps deployed (90) and Chinook and coho salmon smolt CPUE from 2013-2015.

		Chinook salmon smolt		Coho salmon smolt	
Date	Traps deployed	CPUE 2013-2015	Valid CWT	CPUE 2013-2015	Valid CWT
4-Apr	90	1.4	126	2.6	233
5-Apr	90	2.0	181	3.4	307
6-Apr	90	1.4	125	3.1	282
7-Apr	90	1.3	121	3.1	279
8-Apr	90	1.2	110	3.0	271
9-Apr	90	1.1	101	2.5	221
10-Apr	90	1.1	96	2.4	217
11-Apr	90	1.1	101	2.6	236
12-Apr	90	1.2	106	3.3	299
13-Apr	90	1.4	124	3.5	312
14-Apr	90	1.7	155	3.4	305
15-Apr	90	1.3	119	2.8	250
16-Apr	90	1.0	88	2.8	250
17-Apr	90	1.4	126	3.3	301
18-Apr	90	1.7	150	3.2	286
19-Apr	90	1.1	101	3.6	327
20-Apr	90	1.0	87	3.3	293
21-Apr	90	1.0	94	3.8	345
22-Apr	90	0.9	77	3.1	279
23-Apr	90	1.4	130	3.1	276
24-Apr	90	1.9	167	3.5	314
25-Apr	90	1.3	121	2.6	237
26-Apr	90	0.7	62	1.9	173
27-Apr	90	0.9	83	2.7	241
28-Apr	90	1.1	98	2.1	189
29-Apr	90	0.8	76	2.2	195
30-Apr	90	1.6	144	2.9	258
1-May	90	1.2	112	2.7	247
2-May	90	1.1	103	2.5	224
3-May	90	1.3	118	2.5	225
4-May	90	1.1	100	2.3	208
5-May	90	1.0	87	2.7	240
6-May	90	0.7	63	2.6	232
7-May	90	0.6	52	2.8	251
8-May	90	0.6	58	2.4	213
9-May	90	0.8	72	3.2	289
10-May	90	1.0	90	2.8	256
11-May	90	0.8	71	3.2	287
12-May	90	0.3	28	2.7	246
13-May	90	0.3	23	1.8	164
TOTAL	3,600	1.1	4,045	2.8	10,258

Note: The most recent three years' CPUE are used because the trap site selection method changed significantly in 2013.

Appendix A2.–Expected values used in Chilkat Chinook salmon brood year 2014 coded wire tag (CWT) sample size and precision calculations.

	Survival or harvest rate	Percent of Chilkat marine harvest	Number of Chilkat fish	Marked rate	Number of Chilkat CWT fish	Sampling rate	Number of Chilkat CWTs recovered
Fall 2015 juvenile population			474,912				
Fall 2015 marked with CWT				0.053	25,000		
Spring 2016 survivors	35.9%		170,417		8,971		
Spring 2016 CWT marked				0.025	4,045		
Total marked spring 2016 emigrants				0.076	13,016		
Smolt to adult survivors	2.9%		4,905		375		
SEAK marine harvest by fishery							
Winter Troll		6%	55	0.076	4	0.35	1
Spring Troll		23%	200	0.076	15	0.54	8
Summer Troll		11%	93	0.076	7	0.22	2
Drift gillnet		42%	355	0.076	27	0.43	12
purse seine		5%	47	0.076	4	0.28	1
SEAK sport		12%	103	0.076	8	0.41	3
Total SEAK marine harvest	17.4%	100%	853	0.076	65	0.44	27
Haines sport harvest	2.4%		120				
Haines Chilkat Inlet subsistence	1.1%		55				
Total inriver abundance	79.1%		3,878	0.076	296	0.25	73

Appendix A3.–Hypothetical set of marine fishery recoveries of brood year 2014 Chilkat Chinook salmon CWTs used to relate the number of juveniles marked in fall 2015 and spring 2016 to the relative precision of the adult marine harvest estimate. The parameter $\hat{p}$ CWT represents the probability that a Chilkat Chinook CWT will be encountered in each age/time/fishery stratum. Each stratum contains average harvest and sampling rates from 2004 to 2014. Estimated harvest is derived from methods in Bernard and Clark (1996). Troll fisheries are defined as W Troll (winter troll), SP Troll (spring troll), and SU Troll (summer troll).

District / Fishery	SW/BW	Age	$\hat{p}_{CWT}$	$\hat{N}_i$	Var[N_i]	m_i	$\hat{r}_{ij}$	ϕ_i	λ_i	Var[$\hat{r}_{ij}$]	SE[$\hat{r}_{ij}$]	P (m_{ij} > 0)
111 GILLNET	27	1.2	0.182	170	0	0.28	12	41%	1.000	66	8	0.24
111 GILLNET	28	1.2	0.091	9	0	0.14	3	45%	1.000	7	3	0.13
111 GILLNET	29	1.2	0.091	31	0	0.14	4	27%	1.000	20	4	0.13
112 PURSE	27	1.2	0.182	425	0	0.28	20	23%	1.000	207	14	0.24
112 PURSE	29	1.2	0.091	4	0	0.14	1	100%	1.000	1	1	0.13
114 PURSE	29	1.2	0.182	12	0	0.28	6	82%	1.000	16	4	0.24
115 GILLNET	25	1.2	0.273	120	0	0.41	25	43%	1.000	202	14	0.34
115 GILLNET	26	1.2	0.182	76	0	0.28	11	49%	0.917	54	7	0.24
115 GILLNET	27	1.2	0.545	386	0	0.83	126	35%	0.976	2,745	52	0.56
115 GILLNET	28	1.2	0.545	224	0	0.83	71	61%	1.000	839	29	0.56
115 GILLNET	29	1.2	0.455	230	0	0.69	60	49%	1.000	732	27	0.50
115 GILLNET	30	1.2	0.273	95	0	0.41	25	42%	1.000	212	15	0.34
115 GILLNET	31	1.2	0.727	514	0	1.10	170	45%	1.000	3,801	62	0.67
115 GILLNET	32	1.2	0.182	23	0	0.28	7	67%	1.000	24	5	0.24
115 GILLNET	33	1.2	0.364	32	0	0.55	29	66%	1.000	203	14	0.42
115 GILLNET	34	1.2	0.182	18	0	0.28	8	57%	1.000	34	6	0.24
115 GILLNET	37	1.2	0.364	28	0	0.55	27	71%	1.000	174	13	0.42
115 GILLNET	38	1.2	0.182	4	0	0.28	3	150%	1.000	5	2	0.24
JUNEAU SPORT	29-32	1.2	0.364	170	2,595	0.55	21	89%	1.000	142	12	0.42
108 GILLNET	25	1.2	0.091	280	0	0.14	2	56%	1.000	4	2	0.13
112 PURSE	26	1.2	0.091	142	0	0.14	10	12%	1.000	98	10	0.13
SGY SPORT	30	1.2	0.091	5	2	0.14	3	40%	1.000	9	3	0.13

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District / Fishery	SW/BW	Age	$\hat{p}_{CWT}$	$\hat{N}_i$	Var[N_i]	m_i	$\hat{r}_{ij}$	ϕ_i	λ_i	Var[$\hat{r}_{ij}$]	SE[$\hat{r}_{ij}$]	P (m_{ij} > 0)
114 SP TROLL	24	1.2	0.182	104	0	0.28	6	83%	1.000	16	4	0.24
114 SP TROLL	26	1.2	0.091	24	0	0.14	2	61%	1.000	4	2	0.13
114 SU TROLL	33-34	1.2	0.273	226	0	0.41	72	15%	1.000	1,750	42	0.34
110 SU TROLL	34	1.2	0.091	28	0	0.14	2	64%	1.000	3	2	0.13
110 W TROLL	42	1.2	0.182	137	0	0.28	6	79%	1.000	17	4	0.24
113 W TROLL	42	1.2	0.091	27	0	0.14	3	45%	1.000	7	3	0.13
183 W TROLL	43	1.2	0.091	49	0	0.14	4	29%	1.000	16	4	0.13
110 W TROLL	44	1.2	0.091	11	0	0.14	1	82%	1.000	2	1	0.13
110 W TROLL	49	1.2	0.091	9	0	0.14	4	34%	1.000	12	3	0.13
108 GILLNET	24	1.3	0.091	119	0	0.14	2	52%	1.000	5	2	0.13
111 GILLNET	27	1.3	0.091	53	0	0.14	3	37%	0.941	11	3	0.13
112 PURSE	25	1.3	0.091	95	0	0.14	2	49%	1.000	6	2	0.13
115 GILLNET	25	1.3	0.182	80	0	0.28	10	50%	1.000	44	7	0.24
115 GILLNET	26	1.3	0.273	147	0	0.41	33	33%	1.000	357	19	0.34
115 GILLNET	27	1.3	0.909	958	0	1.38	294	41%	1.000	9,262	96	0.75
115 GILLNET	28	1.3	0.545	196	0	0.83	75	57%	1.000	962	31	0.56
115 GILLNET	29	1.3	0.545	81	0	0.83	70	61%	1.000	830	29	0.56
115 GILLNET	30	1.3	0.091	2	0	0.14	1	106%	1.000	1	1	0.13
115 GILLNET	31	1.3	0.091	2	0	0.14	1	88%	1.000	2	1	0.13
115 GILLNET	32	1.3	0.091	7	0	0.14	1	84%	1.000	2	1	0.13
115 GILLNET	33	1.3	0.091	2	0	0.14	2	68%	1.000	3	2	0.13
GUSTAVUS SPORT	23	1.3	0.091	5	2	0.14	1	88%	1.000	2	1	0.13
JUNEAU SPORT	22-36	1.3	0.636	549	27,081	0.96	98	60%	1.000	2,126	46	0.62
108 GILLNET	27	1.3	0.182	660	0	0.28	19	25%	0.986	181	13	0.24
SKAGWAY SPORT	26-32	1.3	0.273	26	59	0.41	16	68%	1.000	95	10	0.34

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District / Fishery	SW/BW	Age	$\hat{p}_{CWT}$	$\hat{N}_i$	Var[N_i]	m_i	$\hat{r}_{ij}$	ϕ_i	λ_i	Var[$\hat{r}_{ij}$]	SE[$\hat{r}_{ij}$]	P (m_{ij} > 0)
109 SP TROLL	21	1.3	0.091	19	0	0.14	1	85%	1.000	2	1	0.13
109 SP TROLL	22	1.3	0.182	248	0	0.28	8	60%	0.989	32	6	0.24
112 SP TROLL	24	1.3	0.091	48	0	0.14	2	72%	1.000	3	2	0.13
112 SP TROLL	25	1.3	0.091	43	0	0.14	1	89%	1.000	2	1	0.13
112 SP TROLL	26	1.3	0.091	6	0	0.14	3	38%	1.000	10	3	0.13
113 SP TROLL	21	1.3	0.091	41	0	0.14	4	28%	1.000	18	4	0.13
113 SP TROLL	23	1.3	0.182	544	0	0.28	12	40%	0.990	72	8	0.24
113 SP TROLL	25	1.3	0.091	274	0	0.14	2	48%	1.000	6	2	0.13
114 SP TROLL	20	1.3	0.091	11	0	0.14	3	46%	1.000	6	3	0.13
114 SP TROLL	21	1.3	0.455	551	0	0.69	58	51%	1.000	689	26	0.50
114 SP TROLL	22	1.3	0.273	348	0	0.41	15	73%	1.000	69	8	0.34
114 SP TROLL	23	1.3	0.182	94	0	0.28	10	49%	1.000	46	7	0.24
114 SP TROLL	24	1.3	0.818	1604	0	1.24	151	64%	1.000	2,662	52	0.71
114 SP TROLL	25	1.3	0.364	1109	0	0.55	43	44%	1.000	473	22	0.42
114 SP TROLL	26	1.3	0.091	26	0	0.14	4	28%	1.000	17	4	0.13
114 SU TROLL	27	1.3	0.182	59	0	0.28	38	13%	1.000	709	27	0.24
114 SU TROLL	28	1.3	0.091	88	0	0.14	9	14%	0.923	87	9	0.13
116 SU TROLL	29	1.3	0.091	141	0	0.14	5	25%	1.000	22	5	0.13
110 W TROLL	42	1.3	0.091	73	0	0.14	5	23%	1.000	27	5	0.13
113 W TROLL	12	1.3	0.091	296	0	0.14	4	33%	0.984	13	4	0.13
113 W TROLL	42	1.3	0.091	110	0	0.14	6	21%	1.000	30	5	0.13
183 W TROLL	46	1.3	0.091	57	0	0.14	6	21%	1.000	31	6	0.13
104 PURSE	28	1.4	0.091	31	0	0.14	3	43%	1.000	8	3	0.13
115 GILLNET	27	1.4	0.182	42	0	0.28	12	40%	1.000	69	8	0.24
115 GILLNET	30	1.4	0.091	1	0	0.14	1	114%	1.000	1	1	0.13

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Appendix A3.–Page 4 of 4.

District / Fishery	SW/BW	Age	$\hat{p}_{CWT}$	$\hat{N}_i$	$Var[N_i]$	m_i	$\hat{r}_{ij}$	ϕ_i	λ_i	$Var[\hat{r}_{ij}]$	$SE[\hat{r}_{ij}]$	P (m_{ij} > 0)
GUSTAVUS SPORT	12	1.4	0.091	14	17	0.14	1	100%	1.000	1	1	0.13
JUNEAU SPORT	21	1.4	0.091	63	359	0.14	8	15%	1.000	65	8	0.13
JUNEAU SPORT	22	1.4	0.091	41	150	0.14	7	21%	0.833	46	7	0.13
JUNEAU SPORT	25	1.4	0.091	20	37	0.14	3	35%	1.000	11	3	0.13
SITKA SPORT	23	1.4	0.182	1382	171,938	0.28	12	41%	0.992	74	9	0.24
105 SP TROLL	21	1.4	0.091	13	0	0.14	4	33%	1.000	13	4	0.13
105 SP TROLL	24	1.4	0.091	9	0	0.14	1	94%	1.000	1	1	0.13
109 SP TROLL	20	1.4	0.091	53	0	0.14	1	87%	1.000	2	1	0.13
109 SP TROLL	22	1.4	0.091	103	0	0.14	2	75%	0.988	2	2	0.13
113 SP TROLL	20	1.4	0.091	30	0	0.14	2	63%	1.000	3	2	0.13
113 SP TROLL	21	1.4	0.091	278	0	0.14	2	52%	1.000	5	2	0.13
113 SP TROLL	22	1.4	0.091	96	0	0.14	2	55%	0.976	5	2	0.13
113 SP TROLL	23	1.4	0.091	195	0	0.14	2	52%	0.984	5	2	0.13
113 SP TROLL	24	1.4	0.091	175	0	0.14	3	42%	0.971	8	3	0.13
113 SP TROLL	25	1.4	0.091	212	0	0.14	2	55%	1.000	4	2	0.13
114 SP TROLL	21	1.4	0.091	44	0	0.14	2	55%	1.000	4	2	0.13
114 SP TROLL	22	1.4	0.182	89	0	0.28	11	44%	1.000	56	7	0.24
114 SP TROLL	23	1.4	0.182	45	0	0.28	10	49%	1.000	46	7	0.24
114 SP TROLL	24	1.4	0.091	43	0	0.14	3	45%	1.000	7	3	0.13
114 SP TROLL	26	1.4	0.091	30	0	0.14	3	45%	1.000	7	3	0.13
183 SP TROLL	20	1.4	0.091	5	0	0.14	1	100%	1.000	1	1	0.13
YAKUTAT SPORT	21	1.4	0.091	6	3	0.14	2	52%	1.000	5	2	0.13
JUNEAU SPORT	22	1.5	0.091	106	1,018	0.14	9	16%	0.900	72	8	0.13
TOTAL						27	1,873	*90% RP= 15.4%*		30,857	176	

Appendix A4.–Simulation data and statistics for anticipating precision of the estimated harvest of Chilkat River coho salmon from marine sport and commercial fisheries in 2017.

Stratum (type,area,wks)	N_i	Var[N_i]	$(n_i/N_i)_i$	m	λ_i	r_i	se[r_i]	π_i	$1-(1-\pi i)^H$
Troll, NW 3	489,346	0	28%	9.3	0.98	4,139	1,382	0.000907	1.000
Troll, NE 4	62,313	0	28%	1.2	0.99	519	476	0.000116	0.696
Troll, NW 4	420,488	0	35%	49.6	0.98	17,895	2,814	0.004832	1.000
Troll, NW 5	139,380	0	28%	2.2	0.99	955	648	0.000212	0.887
Sport, Gustavus Ma, 12-18	29,636	7447441	10%	0.0	0.97	41	230	0.000003	0.031
Sport, Icy St Ma, 11-18	14,927	5760978	47%	0.9	1.00	224	241	0.000084	0.576
Sport, Juneau Ma, 17	7,400	1120364	58%	0.5	0.97	114	156	0.000051	0.405
Sport, Juneau Ma, 18-19	6,956	2503384	27%	0.6	0.92	320	396	0.000062	0.473
Sport, Sitka Ma, 14	9,614	11525161	24%	0.0	0.97	17	87	0.000003	0.031
Sport, Sitka Ma, 17	18,032	6062031	30%	0.1	0.97	38	125	0.000009	0.087
Sport, Yakutat Ma, 16-18	5,484	1394020	65%	0.2	1.00	43	88	0.000022	0.202
Gillnet, 111, 38	10,901	0	15%	0.1	0.98	50	206	0.000006	0.058
Gillnet ,115, 34	1,990	0	34%	0.9	1.00	313	335	0.000085	0.581
Gillnet, 115, 35	3,839	0	46%	3.4	0.96	949	517	0.000331	0.966
Gillnet,115, 36	6,786	0	29%	6.8	1.00	2,906	1,127	0.000665	0.999
Gillnet, 115, 37	10,040	0	22%	6.1	0.99	3,446	1,405	0.000599	0.998
Gillnet, 115, 38	11,900	0	21%	5.6	0.97	3,376	1,443	0.000544	0.996
Gillnet, 115, 39	8,451	0	32%	12.1	0.98	4,760	1,401	0.001182	1.000
Gillnet, 115, 40-41	3,694	0	36%	5.1	0.99	1,774	789	0.000501	0.994

-continued-

Stratum (type,area,wks)	N_i	Var[N_i]	$(n_i/N_i)_i$	m	λ_i	r_i	se[r_i]	π_i	$1-(1-\pi i)^H$
Seine, 109, 31	44,672	0	13%	0.0	0.99	31	172	0.000003	0.031
Seine, 109, 32	9,660	0	22%	0.0	0.99	25	118	0.000004	0.045
Seine, 112, 30	6,455	0	15%	0.1	0.99	90	268	0.00011	0.105
Seine, 112, 31	6,555	0	32%	0.0	0.99	17	81	0.00004	0.045
Seine, 112, 33	2,284	0	80%	0.1	0.99	14	47	0.00009	0.087
Seine, 112, 34	11,911	0	40%	0.3	0.99	82	159	0.00026	0.236
Seine, 112, 35	15,508	0	16%	0.1	0.99	69	228	0.00009	0.087
Seine, 114, 31	6,377	0	53%	0.0	0.99	7	42	0.00003	0.031
Seine, 114, 34	1,136	0	26%	0.0	1.00	20	98	0.00004	0.042
Seine, 114, 38	1,993	0	21%	0.1	1.00	54	179	0.00009	0.086
Total	1,367,726	35,813,379	30%	106		42,289	4,402	**90% r.p.=17.1%**	0.000

Note: Based on an anticipated release in 2016 of 10,258 tagged smolt from a population of 1,259,342.

Note: The term π_i is the average historical probability (from sampling in 2000–2014) of recovering a tag in a stratum, and $1-(1-\pi_i)^H$ is the anticipated probability recovering a tag in that stratum (i.e., prob(m>0)); see Bernard et al. (1998) for other details.

Appendix A5.–WinBUGS code and results of Bayesian statistical analysis of BY 2005 juvenile Chinook River salmon abundance.

---

data from other recoveries included, non-valid tags considered

prior distributions for root nodes in italics

fixed constants in bold

deterministic relationships in black (these link the priors and the likelihoods, or calculate auxiliary quantities)

likelihood (sampling distribution of data) underlined

2005 BY constants

adclips <- 70 **# ad clips found**

heads <- 45 **# heads collected (this is actually not relevant here)**

valid.tags <- 44 **# tags decoded**

model {

N.juvenile ~ dnorm(0,1.0E-12) *# abundance of juveniles in fall*

phi.1 ~ dbeta(0.1,0.1) *# proportion of juveniles surviving until spring*

rho ~ dbeta(0.1,0.1) *# proportion of ad clipped fish for which head collected and tag decoded*

M.juvenile <- 18,318 **# juveniles marked**

M.smolt <- 2,238 **# smolt marked**

C <- 814 **# fish inspected inriver for ad clips**

m<-20 **# number of Chilkat CWT recoveries elsewhere, fall and spring**

N.smolt <- N.juvenile * phi.1 # abundance of smolt the following spring

q.fall <- M.juvenile / N.juvenile # fraction marked in fall

q.spring <- M.smolt / N.smolt # fraction marked in spring

pi[1] <- q.fall * rho # fraction of returning fish from which could expect a valid fall tag

pi[2] <- q.spring * rho # fraction of returning fish from which could expect a valid spring tag

pi[3] <- (q.fall + q.spring) * (1 - rho) # fraction of returning fish with adclip, but no valid tag

pi[4] <- 1 - pi[1] - pi[2] - pi[3] # fraction with no adclip

R.tags[1:4] ~ dmulti(pi[],C) # vector of returns by type is multinomially distributed

pi.fall <- q.fall / (q.fall + q.spring) # fraction of fall tags among all Chilkat tags

m.fall ~ dbin(pi.fall,m) # number of fall tags among Chilkat tags is binomially distributed

--continued--

DATA

list(R.tags=c(39,5,26,743),m.fall=18) # terms in DATA list are:39 fall tags in Chilkat escapement,
5 spring tags in Chilkat escapement; 26 heads not taken or
tags not decoded; 743 fish with intact adipose fins;
18 fall tags recovered in marine random samples.

INITS

list(N.juvenile =239000, phi.1=0.6, rho=0.6)

RESULTS

node	mean	sd	MC error	2.50%	10.00%	median	90.00%	97.50%	start	sample
N.juvenile	249,100	29,570	135	198,500	213,500	246,700	288,000	313,900	4,001	96,000
N.smolt	222,900	38,530	158	140,300	171,800	224,800	269,600	295,300	4,001	96,000
phi.1	0.8976	0.1295	6.55E-04	0.5515	0.6955	0.9569	0.9998	1.0000	4,001	96,000
pi[1]	0.0468	0.0070	2.58E-05	0.0341	0.0382	0.0465	0.0559	0.0613	4,001	96,000
pi[2]	0.0065	0.0015	5.28E-06	0.0045	0.0050	0.0063	0.0083	0.0102	4,001	96,000
pi[3]	0.0316	0.0061	1.79E-05	0.0208	0.0240	0.0312	0.0396	0.0446	4,001	96,000
rho	0.6282	0.0575	1.07E-04	0.5125	0.5533	0.6295	0.7013	0.7369	4,001	96,000

APPENDIX B

Appendix B1.–Smolt coded wire tag daily log.

Tagging Site: Chilkat River

Species: Coho

Capture Site: Chilkat River

Tagger: Derby

Date: May 5, 2013

Today's Tagging: Machine Serial No.___621___________

	SMALL	**MEDIUM**	**LARGE**
Tag Code	04-18-93	04-18-94	04-18-94
End #	276,633	275,822	276,204
Start #	276,209	275,513	275,824
Subtotal	424	309	380
Double/Retags	0	2	12
Total Tagged	424	307	368

Today's Recaptures:

Total w/o CWTs	29
Total w/ CWTs	0
Total	29

Tag Retention & Mortality Calculations (hold until next day):

No. w/ CWTs	100
No. w/o CWTs	0
No. Tested	100

Summary	# valid tagged	overnight mortality	# released
75–84mm	424	1	423
85–99mm	307	0	307
>=100mm	368	2	366
TOTAL	1099	3	1096

Appendix B2.–Instructions for juvenile salmon trapping.

Traps will be tied off with an overhand knot followed by a slipknot to insure traps can be pulled quickly during floodwaters. Try to tie off well above the water level in case of rising water. Always push flagging up to the knot and place extra flagging if not easily visible. Cinch the knot on the flagging tape tight so wind won't blow it into the water. Always carry extra flagging and use it if traps are in hard to find locations.

One crew leader will be in charge of a trap line, and the other will be in charge of the other trap line. Keep accurate track of all traps. **REMEMBER**: Lost traps keep fishing and kill fish. Count all traps taken out to the field at the beginning of the season and record this number in the logbook. If more traps are taken to the field later on, these need to be recorded as well. All lost or damaged traps (i.e., bear hits) will be recorded, and the damaged traps kept in a certain place until the end of the season. The goal is to be able to reconcile the number of traps we have upon pulling out from an area with the number taken out to the field, as even one trap potentially left set is a problem. Also in early–mid May, eulachon will be running in the lower river. Be sensitive to people fishing for eulachon. It may be best to stay out of the lower river during this time.

Both crews should take hand counters to help keep track of the number of traps on the longer lines. If a trap is lost during high water, it should be marked as lost in the trap-line book and the area flagged so the trap may be recovered at low water.

Name specific areas of the river where you are trapping. Naming an area after a natural feature will help you associate the area with the name. Examples are Spruce Row, Moose Bar and Big Beaver. So that everyone is using a standard method of notation in the trap-line field book, the format will be as follows:

Table 1.–Example of data collected and recorded in the field during smolt trapping efforts on the Unuk River in Fall, 2003.

Date: 10/20/2003					
Site	Traps checked	Traps pulled	Traps added	Total traps	# Of fish by species
Spruce Row	5	2	0	3	30 coho; 10 king
Moose Bar	2	0	2	4	50 coho
Big Beaver	3	3	0	0	5 coho
Snowball	0	0	3	3	New sets
Total	10	5	5	10	85 coho; 10 king

According to the above notation, at Spruce Row we checked 5 traps; two of the traps didn't catch many fish so we pulled them. That leaves us with 3 traps in that area and we caught approximately 30 fish there. On Moose Bar we checked 2 traps and caught 50 fish so we set 2 more in that area, for a total of 4 traps in the water. At Big Beaver we checked 3 traps for a total of 5 fish, lousy fishing so we pulled all 3 traps, leaving us with 10 traps in that area. We set 3 traps in a new area called Snowball. Looking at the total we see that we caught 85 coho and 10 kings that day and have 10 traps still in the water fishing.

The rest of the crew will alternate between upriver and downriver to break up the monotony of always working with the same person.

The number of traps out is the important number. Don't waste a lot of time counting each individual fish. We will get the exact number when we tag. Be conservative in your counting. The objective is to tag a lot of fish, not to have a higher number in your book than the other crew.

Appendix B3.–Minnow trap summary form. A7

	River	River	Lower Trapline				Upper Trapline				Daily Total				Cum. Total	
	Depth	Temp	Number of traps		Est. Fish		Number of traps		Est. Fish		Est. Fish		# Tagged		# Tagged	# Tagged
Date	(in)	(C)	Checked	Set	Chinook	Coho	Checked	Set	Chinook	Coho	Chinook	Coho	Chinook	Coho	Chinook	Coho
8-Apr	6.00	2.0		50				40								
9-Apr	6.50	2.0	50	44	37	144	40	50	48	285	85	429				
10-Apr	7.00	2.0	44	40	39	201	50	36	39	432	78	633	160	1,162	160	1,162
11-Apr	7.25	3.0	40	46	26	118	36	47	39	284	65	402				
12-Apr	8.00	3.0	46	35	9	120	47	42	29	218	38	338	85	658	245	1,820
13-Apr	10.00	3.0	35	36	6	64	42	47	35	231	41	295				
14-Apr	11.50	3.0	36	50	28	85	47	47	24	221	52	306	74	553	319	2,373
15-Apr	13.50	2.5	50	46	23	91	47	50	8	180	31	271				
16-Apr	14.50	3.0	46	43	28	277	50	49	11	174	39	451	69	666	388	3,039
17-Apr	16.25	3.0	43	46	33	188	49	49	37	238	70	426				
18-Apr	16.75	2.5	46	40	21	144	49	49	84	311	105	455	138	714	526	3,753
19-Apr	17.00	3.0	40	48	33	174	49	50	66	231	99	405				
20-Apr	18.00	4.0	48	46	40	290	50	50	49	193	89	483	203	772	729	4,525
21-Apr	19.00	3.0	46	46	51	216	50	50	39	145	90	361				
22-Apr	19.00	3.0	46	46	26	201	49	49	68	171	94	372	150	389	879	4,914
23-Apr	19.25	2.5	46	48	12	143	49	48	48	270	60	413				
24-Apr	19.25	3.0	48	47	22	140	48	48	59	263	81	403	129	649	1,008	5,563
25-Apr	19.00	3.0	47	47	37	143	48	48	74	222	111	365				
26-Apr	19.00	3.0	47	46	43	147	48	48	88	174	131	321	222	653	1,230	6,216
27-Apr	19.00	3.0	46	48	65	184	48	48	114	256	179	440				
28-Apr	20.75	4.0	48	49	49	134	48	48	146	198	195	332	382	675	1,612	6,891
29-Apr	21.00	4.0	49	49	79	167	48	48	95	206	174	373				
30-Apr	22.00	4.0	49	49	50	157	48	48	142	292	192	449	357	577	1,969	7,468
1-May	22.00	4.0	49	45	58	96	48	46	147	321	205	417				
2-May	22.75	4.0	45	46	94	146	46	50	88	241	182	387	373	775	2,342	8,243
3-May	23.00	4.0	46	50	93	207	50	50	54	208	147	415				
4-May	23.00	4.0	50	50	57	173	50	49	41	265	98	438	232	748	2,574	8,991
5-May	22.75	4.0	50	50	20	139	49	48	37	309	57	448				
6-May	23.00	4.0	50	50	25	266	48	48	37	222	62	488	88	767	2,662	9,758
7-May	24.00	4.5	50	50	18	239	48	49	34	263	52	502				
8-May	26.75	4.0	50	50	14	133	49	49	40	222	54	355	104	737	2,766	10,495
9-May	26.00	3.5	50	50	7	262	49	49	64	285	71	547				
10-May	24.50	4.0	50	50	6	146	49	49	47	238	53	384	108	727	2,874	11,222
11-May	24.50	4.5	50	49	17	209	49	49	27	269	44	478				
12-May	27.00	4.0	49	49	8	176	49	49	25	220	33	396	64	740	2,938	11,962
13-May	27.75	4.0	49	49	18	192	49	49	15	244	33	436				
14-May	26.50	4.5	49	48	24	207	49	49	12	282	36	489	67	801	3,005	12,763

Appendix B4.–Chilkat River Chinook salmon sampling form.

Gear: Location:

Fish #	**Date**	**Length**	**Fish #**	**Date**	**Length**

Appendix B5.–Chilkat River coho salmon smolt age-weight-length form.

Location: ______________ **Year:** _______

Species: ______________ **Page :** _______

Samplers:

Date	Slide	Fish #	Length	Weight	Comments	Date	Slide	Fish #	Length	Weight	Comments
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			
		1						1			
		2						2			
		3						3			
		4						4			

Appendix B6.–Coded wire tag online release entry report.

CWT Online Release Entry Final Notification, Tag Code: 041546

Tag Code:	041546	Beg. Seq.:		End. Seq.:	

General Information

Project Leader:	RICHARD CHAPELL	Species:	COHO	Rearing Type:	WILD
Agency:	ADFG	Brood Year:	2007	Release Type:	
Division/Section:	SPORT FISH	Stock:	CHILKAT RIVER	Run:	SUMMER
Facility:		Ancestral Stock:		Mark Type Code:	AD
Experimental Class:				Thermal Mark:	

Experimental Narrative: 250 characters max.

WILD COHO SALMON (SIZE RANGE >=85MM FROM BY2006 AND BY2007) CAUGHT, TAGGED, AND RELEASED IN THE CHILKAT RIVER 5/16/2009 - 5/30/2009. TAG RETENTION PERFORMED ON MIXED SAMPLE OF FISH; SAMPLE SIZE PROPORTIONED ACCORDINGLY.

Statistical Replicates:

Tagging Information

Tagging Supervisor:	LARRY DERBY	Size of Tagged Fish:	grams	Naturally Missing Ad Fins:	

Date	Mach. Number	Number Injected	Overnight Mortality	Adj. Tagged	Tag Retention Sample Ratio	% Tag Retention	Valid Tagged
5/16/2009	621	691	2	689	50 / 50	100.0%	689
5/18/2009	621	727	1	726	50 / 50	100.0%	726
5/20/2009	621	778	6	772	50 / 50	100.0%	772
5/22/2009	621	1,121	17	1,104	50 / 50	100.0%	1,104
5/24/2009	621	913	4	909	50 / 50	100.0%	909
5/26/2009	621	944	18	926	50 / 50	100.0%	926
5/28/2009	621	517	1	516	50 / 50	100.0%	516
5/29/2009	621	271	2	269	50 / 50	100.0%	269

Total Number Injected:	5,962	Total Overnight Morts:	51	Total Adjusted Tagged:	5,911
Average Tag Retention:	100.0%	Total Retention Sample:	400	Total Valid Tagged:	5,911

Release Information

Release Supervisor:	BRIAN ELLIOTT	Release Stage:	SMOLT
Release Site:	CHILKAT RIVER	Unmarked Counting Method:	
Stream #:	115-32-10250-%	Expected Survival:	NORMAL
Time of Release (Military Format):	0900	Release Strategy:	

Release Dates Began	Release Dates Ended	Date of Final Tag Retention Test	Tag Retention Sample Ratio	% Tag Retention	Size at Release Weight	Size at Release Fork Length
5/17/2009	5/30/2009	5/30/2009	50 / 50	100.0%		

Total injected	Overnight morts	Morts after tagging	Surviving tagged fish	Tag retention best estimate
5,962	51		5,911	100.0%

Marked Fish Having Tags	Marked Fish That Shed Tags	Fish Released NOT Marked but Represented	Failed Marks	Total Unmarked Fish Released	Total Fish Released	Tag Ratio
5,911	0		0		5,911	1.000

Comments: 250 characters max.

WILD COHO SALMON SMOLT TAGGED IN "MEDIUM" AND "LARGE" CATEGORY (SIZE >=85MM FROM BY2006 AND BY2007), SEPARATE FROM SMALL (>=75MM - <85MM) COHO SALMON SMOLT

APPENDIX C

Appendix C1.–Global positioning system data collection protocol.

Overview of the Global Positioning System (GPS)

The Global Positioning System (GPS) is a world-wide radio-navigation system formed from a constellation of 24 satellites with precise atomic clocks orbiting 11,000 km above the earth's surface, and their associated ground stations. Positions on earth are determined by receiving the radio signals being emitted, and measuring the very precise distances and time to the available satellite(s); the process uses mathematical 'triangulation' calculations to compute the result.

Essentially, four visible satellites are necessary to accurately determine position, but three available satellites can do the same—albeit sometimes less reliably, depending on their constellation/configuration at that specific point in time. The steep terrain associated with certain parts of Alaska will at times present problems with obstructed views of the sky and therefore will play a role in how well the radio signals from the satellites are being received. However, use of external antennas, leaving units turned on over the course of the day while surveying, and waiting until certain times of day to collect data can all enhance ones ability to collect reasonably precise positions.

GPS Instrument Setup

There are a myriad of makes and models of consumer-grade GPS units available for purchase, but in the end, they all process and produce positional data the same. Before GPS units can be used for navigation or waypoint storage purposes, they need to be initialized. Each GPS receiver should only need to be initialized the first time the unit is used, or if it has been stored for several months or moved a substantial distance while turned off. The initialization procedure is automatic for most GPS receivers and begins on power-up. To initialize a unit for the first time, take the GPS receiver outside with a clear, 360 degree field of view and turn it on. Navigate through the 'pages' of the GPS using the LCD display until the unit shows that it is acquiring satellites. The unit will begin acquiring fixes on available satellites, and storing the orbital data for each in an almanac in memory on the unit. This setup should complete the initialization of the unit.

There are two key items to remember when using consumer-grade GPS units relative to coordinate data being saved/recorded: 1) coordinate information stored directly on the unit (as waypoints or routes) is always stored in a world geographic coordinate system (WGS84) datum and cannot be overridden until they are downloaded; and 2) you can override the datum and projection being displayed on the screen using the setup menu as necessary, <u>but it is important to document what you set the datum/projection to (i.e. NAD83 Stateplane Alaska Zone 1)</u> if recording those coordinates onto a data form/book rather than saving as waypoints on the unit—this is imperative to ensure correct display in GIS for rendering final output.

Observers should always attempt to get the best possible "fix" from satellites when taking a GPS reading. Often, fixes with accuracy (or error, as it is labeled with some GPS units) under 15 m are possible in less than 30 seconds, especially on the larger river systems where canopy cover is minimal, and the view of the horizon is not obscured (e.g., high ridge immediately above river bank). There will be days when the constellation of the satellites is insufficient to allow for good fixes (i.e., >15 m accuracy); in these instances, it is preferred that GPS locations be acquired on a return visit. If no return visit is anticipated, then observers should spend an extra 1–2min, if possible, to let the GPS instrument acquire the best fix under the circumstances.

Importance of Spatial Data to Fisheries Management and Research

Like many resource management agencies across the country, the Alaska Department of Fish and Game's mission is to protect, maintain and improve the fish, game and aquatic plant resources of the state. And almost everything that is done in our day-to-day activities, or conveyed to the public, is explicit to somewhere on the landscape. For example, research project plans typically describe specific locations where data need to be collected; news releases typically describe where users may or may NOT harvest resources, etc. Yet there is no standardized way to document where exactly these places are across the landscape and worse yet, no data management system to accommodate that type of information. Our intent is to layout some guidelines that can be used by others to assist in their spatial data collection efforts.

Spatial data when added to fish observation data is a very useful tool, and can help facilitate a number of information needs for enhancing our ability to carry out the mission of the Department. Examples include: increasing our knowledge of fish distribution for purposes of protection and conservation; documenting where boundary markers are established for fishery openings; documenting where fish are trapped/observed during sampling events for return trips; use of site-specific fish locations to develop landscape-based models that estimate fish production; identifying areas on the landscape that are most important to users for purposes of conservation and protection.

GPS Data Collection Procedures for use in Salmon Stock Assessment Projects

Smolt Tagging (Fall, Spring)

This section will describe the development and implementation of procedures and techniques for the collection of spatial data using GPS units at specific locations on the ground associated with smolt trapping sites on several Transboundary River Systems. These projects include coded wire tagging of Chinook and coho salmon presmolts and smolts which is a component of full stock assessment projects.

First and foremost, SF crews are NOT being asked to change their mode of operations, as it pertains to smolt trapping methods. Rather, the collection of spatial data using GPS units (waypoints) should be considered a task that occurs coincidentally with their delegated smolt trapping work. Generally, you will be looking to collect waypoints at smolt-trapping sites to generally describe the extent of the smolt-trapping area. For example, if we knew that trapping sites were all the same size and configuration, we could simply grab one waypoint for a group of traps known collectively to encompass site 'X'. However, the reality is that these trapping sites differ in size and configuration and migrate upstream/downstream as water levels rise and fall across the trapping season. The general practice is that vernacular names are assigned to these trapping areas in a given season, and rather than re-naming those areas where traps are moved only short distances, typically retain the same name. In other instances, SF crews move into new areas as snow/ice dissipate, at which time the area is assigned a new generic name.

Capturing waypoints in a manner that represents the whole extent or area of individual trapping sites can accommodate each of these scenarios. This may be as simple as taking single waypoints at small sites (which may represent 4–5 traps placed at a small logjam) or as involved as taking multiple waypoints to accurately determine the boundaries of a relatively larger trapping site. It may also entail taking additional waypoints as a single trapping site is fished out and traps are 'shifted' or moved down/up stream; field crews may decide to keep their generic site name, since its in close proximity. One additional waypoint may be sufficient such that we would be able to map out the entire extent of the trapping area.

The bottom line is that multiple waypoints are collected at each site to generally describe the extent of the area being trapped. If two waypoints are collected for a single trapping area, generally identifying the upper and lower portions of the site and a few traps are below or above these waypoints by 20–30 meters, this is fine. We are looking for a precision of under 50 meters in most cases although 100 meters may be the best we can do in large braided areas of the Unuk floodplain, without unduly creating chaos for field crews where the primary responsibilities are trapping large numbers of fish. Figures 1–3 illustrate the use of waypoints in delineating or 'outlining' the extent of trap sites (areas) with an acceptable level of precision. In these figures, the polygons representing the trap sites (areas) may appear to be arbitrarily drawn, considering that although the points fall inside, they do not provide all the corners. We should note that stream banks and islands present obvious boundaries for the delineation of smolt trapping areas in absence of other information, and will be evaluated using aerial photography during delineation in the office to map the site extent.

The collection of waypoints associated with individual trap sites (areas) should accompany trap data in field notebooks used by research staff. This would include recording the GPS Model/Make (Magellan 320, Garmin 12XL, Garmin 450, etc), assigned Unit letter (e.g., L, M, N, etc), the waypoint number, the GPS positional error (or accuracy), and a very brief description of what the individual waypoint represents (e.g., upper most river right or lowest point on river left, etc). If only one GPS unit model (Garmin 12XL, Magellan 320, etc) is used by a crew throughout the smolt trapping season, then it will be unnecessary to record this information daily; just make sure the relevant unit information is on the first page of each field notebook used. One additional piece of information to be recorded includes species and fish numbers. If this data is generally collected concurrent with checking trap lines, then it should be recorded in field notebooks. This information will accompany trap related records associated with the trap site (area), which field crews collect each day, such as number of traps placed, number of traps checked, number of fish, number of traps pulled, etc. **An example of the data collected during smolt trapping which captures all the relevant GPS data is provided in Table 1**. Note that if sites shift, field crews should take another waypoint on the day they are shifted or moved, which depicts the extension of the trapping area (site), and code this information in their field notebooks.

If traps are placed in areas where no site name is given (especially locations where only 1 or 2 traps are placed), specific comments should include a concise description of the general location (e.g., on small tributary to main channel approximately 250 m from the main channel or in beaver pond complex on west side of main channel approximately 400 m from the main river channel).

In general, observers should *always describe features as to right or left as if they were looking downstream (e.g., confluence right bank)*—in other words, "**going with the flow**".

Table 1.–Example of data collected and recorded in the field during smolt trapping efforts on the Unuk River in Fall, 2003.

Date: 10/20/2003 GPS Unit Model: Magellan 320, (unit L)

Site	Traps checked	Traps pulled	Traps added	Total traps	# of fish by species	Way-point #	Waypoint Accuracy (m)	Waypoint description
Spruce Row	5	2	0	3	30 coho; 10 king	5,6	10; 10	5 – upper; 6 – lower
Moose Bar	2	0	2	4	50 coho	7,8	8, 12	7– upper; 8 – lower
Big Beaver	3	3	0	0	5 coho	9	13	Center of trap area
Snowball	0	0	3	3	New sets	10, 11	6, 9	10 – upper; 11 – lower
Total	10	5	5	10	80 coho; 10 king			

In summary, coordinate data should be recorded at all CWT trapping sites where minnow traps are deployed. As an alternative to recording GPS coordinates at each and every minnow trap being deployed, observers can define the bounds of the area being trapped (e.g., Spaghetti Flats, 6-pack slough). If a site is fairly confined or constrained (e.g. has a defined upper and lower end such as a slough) then 1–2 waypoints should be taken at the upper and lower extents of the upper portion and additional waypoints as necessary taken at the extents of the lower reach. Trapping observations recorded in 'smolt trapping data books' should include the saved waypoint number(s), and include vernacular name assigned to that particular site.

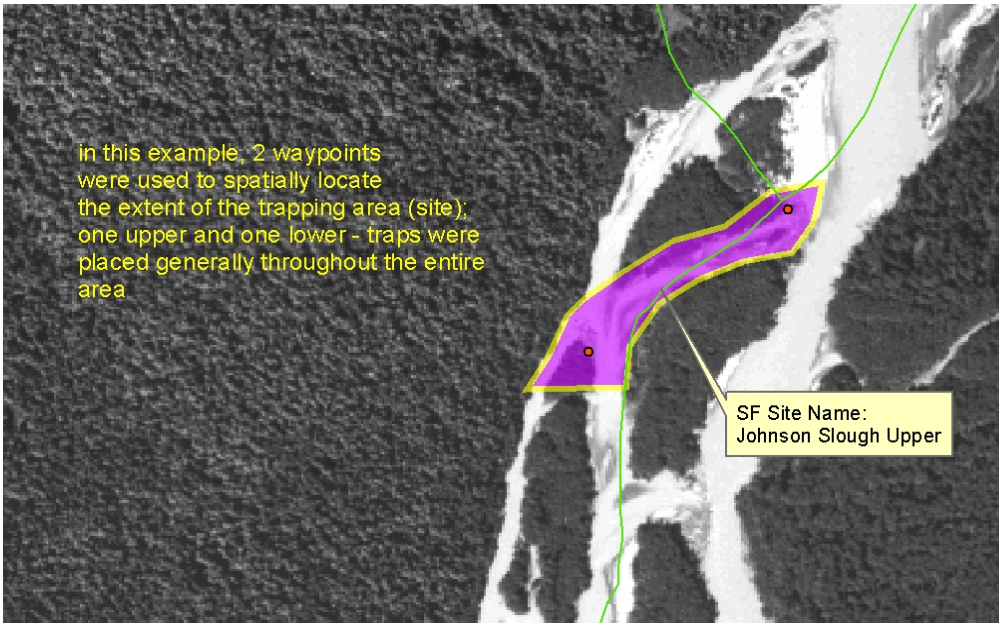

Figure 1.–Smolt trapping site on the Unuk River. The outlined polygon represents a single trapping site or area known as Johnson Slough Upper. Individual trapping sites may contain an infinite number of traps. The orange dots represent 2 waypoints collected to delineate the 'approximate' extent of trapping effort associated with this site.

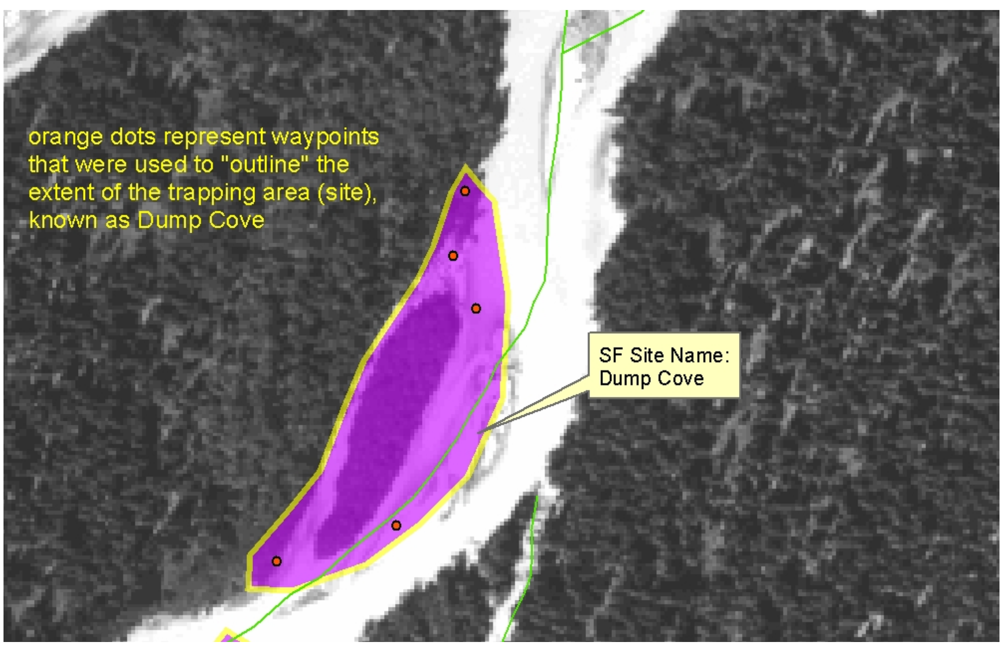

Figure 2.–Using more than two waypoints to delineate the extent of the trap site '*Dump Cove*' on the Unuk River. The upper and lower most waypoints are critical, although the 3 other points allow us to more accurately represent traps that were placed on the river left side of the island.

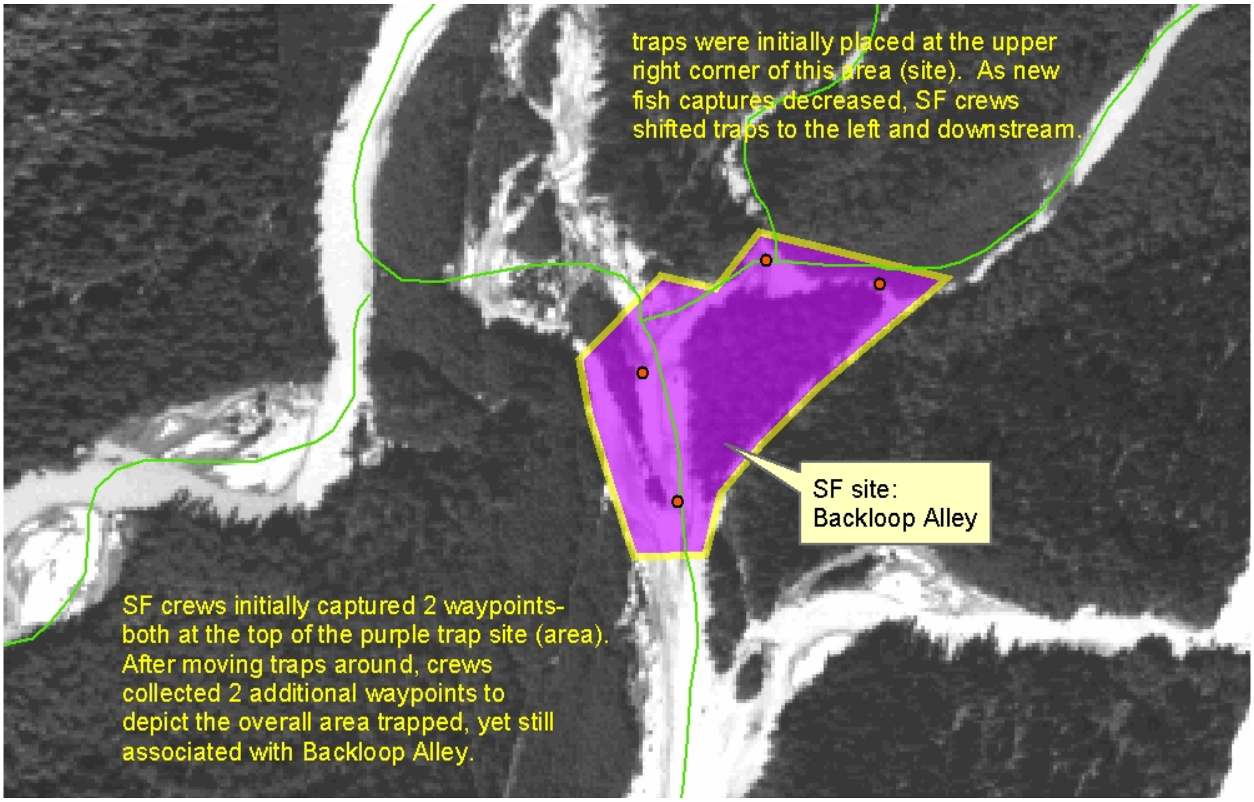

Figure 3.–Example of expanded trap site, and GPS locations used to document that site as local conditions changed due to changing trap catches, and rising and falling water conditions on the Unuk River, Alaska. Again, SF crews shifted traps in response to decreasing numbers associated with initial trap locations (upper portion of polygon). Rather than re-name the SF site, they elected to capture 2 more waypoints associated with new trap locations thereby providing 4 "corners", where we could delineate the Backloop Alley trap site (area).

APPENDIX D

Appendix D1 1.–Detection of size and/or sex selective sampling during a two-sample mark recapture experiment and its effects on estimation of population size and population composition.

Size selective sampling: The Kolmogorov-Smirnov two sample test (Conover 1980) is used to detect significant evidence that size selective sampling occurred during the first and/or second sampling events. The second sampling event is evaluated by comparing the length frequency distribution of all fish marked during the first event (M) with that of marked fish recaptured during the second event (R) by using the null test hypothesis of no difference. The first sampling event is evaluated by comparing the length frequency distribution of all fish inspected for marks during the second event (C) with that of R. A third test that compares M and C is then conducted and used to evaluate the results of the first two tests when sample sizes are small. Guidelines for small sample sizes are <30 for R and <100 for M or C.

Sex selective sampling: Contingency table analysis (Chi^2-test) is generally used to detect significant evidence that sex selective sampling occurred during the first and/or second sampling events. The counts of observed males to females are compared between M&R, C&R, and M&C using the null hypothesis that the probability that a sampled fish is male or female is independent of sample. If the proportions by gender are estimated for a sample (usually C), rather an observed for all fish in the sample, contingency table analysis is not appropriate and the proportions of females (or males) are then compared between samples using a two sample test (e.g. Student's t-test).

M vs. R	**C vs. R**	**M vs. C**
Case I:		
Fail to reject H_o	Fail to reject H_o	Fail to reject H_o

There is no size/sex selectivity detected during either sampling event.

Case II:

Reject H_o	Fail to reject H_o	Reject H_o

There is no size/sex selectivity detected during the first event but there is during the second event sampling.

Case III:

Fail to reject H_o	Reject H_o	Reject H_o

There is no size/sex selectivity detected during the second event but there is during the first event sampling.

Case IV:

Reject H_o	Reject H_o	Either result possible

There is size/sex selectivity detected during both the first and second sampling events.

Evaluation Required:

Fail to reject H_o	Fail to reject H_o	Reject H_o

Sample sizes and powers of tests must be considered:

A. If sample sizes for M vs. R and C vs. R tests are not small and sample sizes for M vs. C test are very large, the M vs. C test is likely detecting small differences which have little potential to result in bias during estimation. *Case I* is appropriate.

B. If a) sample sizes for M vs. R are small, b) the M vs. R p-value is not large (~0.20 or less), and c) the C vs. R sample sizes are not small and/or the C vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the M vs. C test was likely the result of size/sex selectivity during the second event which the M vs. R test was not powerful enough to detect. *Case I* may be considered but *Case II* is the recommended, conservative interpretation.

C. If a) sample sizes for C vs. R are small, b) the C vs. R p-value is not large (~0.20 or less), and c) the M vs. R sample sizes are not small and/or the M vs. R p-value is fairly large (~0.30 or more), the rejection of the null in the

M vs. C test was likely the result of size/sex selectivity during the first event which the C vs. R test was not powerful enough to detect. *Case I* may be considered but *Case III* is the recommended, conservative interpretation.

D. If a) sample sizes for C vs. R and M vs. R are both small, and b) both the C vs. R and M vs. R p-values are not large (~0.20 or less), the rejection of the null in the M vs. C test may be the result of size/sex selectivity during both events which the C vs. R and M vs. R tests were not powerful enough to detect. *Cases I, II, or III* may be considered but *Case IV* is the recommended, conservative interpretation.

Case I. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated after pooling length, sex, and age data from both sampling events.

Case II. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the first sampling event without stratification. If composition is estimated from second event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the M vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case III. Abundance is calculated using a Petersen-type model from the entire data set without stratification. Composition parameters may be estimated using length, sex, and age data from the second sampling event without stratification. If composition is estimated from first event data or after pooling both sampling events, data must first be stratified to eliminate variability in capture probability (detected by the C vs. R test) within strata. Composition parameters are estimated within strata, and abundance for each stratum needs to be estimated using a Petersen-type type formula. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance according to the formulae below.

Case IV. Data must be stratified to eliminate variability in capture probability within strata for at least one or both sampling events. Abundance is calculated using a Petersen-type model for each stratum, and estimates are summed across strata to estimate overall abundance. Composition parameters may be estimated within the strata as determined above, but only using data from sampling events where stratification has eliminated variability in capture probabilities within strata. If data from both sampling events are to be used, further stratification may be necessary to meet the condition of capture homogeneity within strata for both events. Overall composition parameters are estimated by combining stratum estimates weighted by estimated stratum abundance.

If stratification by sex or length is necessary prior to estimating composition parameters, then an overall composition parameters (p_k) is estimated by combining within stratum composition estimates using:

$$\hat{p}_k = \sum_{i=1}^{j} \frac{\hat{N}_i}{\hat{N}_\Sigma} \hat{p}_{ik} \text{ ; and,} \tag{1}$$

$$\hat{V}[\hat{p}_k] \approx \frac{1}{\hat{N}_\Sigma^2} \sum_{i=1}^{j} \left(\hat{N}_i^2 \hat{V}[\hat{p}_{ik}] + \left(\hat{p}_{ik} - \hat{p}_k\right)^2 \hat{V}[\hat{N}_i] \right). \tag{2}$$

where:
- j = the number of sex/size strata;
- $\hat{p}_{ik}$ = the estimated proportion of fish that were age or size k among fish in stratum i;
- $\hat{N}_i$ = the estimated abundance in stratum i; and,
- $\hat{N}_\Sigma$ = sum of the $\hat{N}_i$ across strata.

Appendix D1 2.–Tests of consistency for the Petersen estimator (from Seber 1982, page 438).

TESTS OF CONSISTENCY FOR PETERSEN ESTIMATOR

Of the following conditions, at least one must be fulfilled to meet assumptions of a Petersen estimator:

1. Marked fish mix completely with unmarked fish between events;
2. Every fish has an equal probability of being captured and marked during event 1; or,
3. Every fish has an equal probability of being captured and examined during event 2.

To evaluate these three assumptions, the chi-square statistic will be used to examine the following contingency tables as recommended by Seber (1982). At least one null hypothesis needs to be accepted for assumptions of the Petersen model (Bailey 1951, 1952; Chapman 1951) to be valid. If all three tests are rejected, a temporally or geographically stratified estimator (Darroch 1961) should be used to estimate abundance.

I.-Test For Complete Mixing[a]

Area/Time Where Marked	Area/Time Where Recaptured				Not Recaptured
	1	**2**	**…**	**t**	(n_1-m_2)
1					
2					
…					
s					

II.-Test For Equal Probability of capture during the first event[b]

	Area/Time Where Examined			
	1	**2**	**…**	**t**
Marked (m_2)				
Unmarked (n_2-m_2)				

III.-Test for equal probability of capture during the second event[c]

	Area/Time Where Marked			
	1	**2**	**…**	**s**
Recaptured (m_2)				
Not Recaptured (n_1-m_2)				

[a] This tests the hypothesis that movement probabilities (θ) from time or area i (i = 1, 2, ...s) to section j (j = 1, 2, ...t) are the same among sections: H_0: $\theta_{ij} = \theta_j$.

[b] This tests the hypothesis of homogeneity on the columns of the 2-by-t contingency table with respect to the marked to unmarked ratio among time or area designations: H_0: $\Sigma_i a_i \theta_{ij} = kU_j$, where k = total marks released/total unmarked in the population, U_j = total unmarked fish in stratum j at the time of sampling, and a_i = number of marked fish released in stratum i.

[c] This tests the hypothesis of homogeneity on the columns of this 2-by-s contingency table with respect to recapture probabilities among time or area designations: H_0: $\Sigma_j \theta_{ij} p_j$ = d, where p_j is the probability of capturing a fish in section j during the second event, and d is a constant.